

BMJ Open

BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (<http://bmjopen.bmj.com>).

If you have any questions on BMJ Open's open peer review process please email info.bmjopen@bmj.com

BMJ Open

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

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-041870
Article Type:	Original research
Date Submitted by the Author:	19-Jun-2020
Complete List of Authors:	<p>Marthias, Tiara; The University of Melbourne, Nossal Institute for Global Health; Gadjah Mada University, Department of Public Health, Faculty of Medicine, Public Health and Nursing</p> <p>Anindya, Kanya; The University of Melbourne, Nossal Institute for Global Health</p> <p>Ng, Nawi ; University of Gothenburg, Department of Public Health and Community Medicine</p> <p>McPake, B; The University of Melbourne, Nossal Institute for Global Health</p> <p>Atun, Rifat; Harvard University T H Chan School of Public Health, Department of Global Health and Population</p> <p>Arfyanto, Hafiz ; SMERU Research Institute</p> <p>Hulse, Emily ; The University of Melbourne, Nossal Institute for Global Health</p> <p>Zhao, Yang; The University of Melbourne, Nossal Institute for Global Health, The University of Melbourne</p> <p>Jusril, Hafizah; Universitas Indonesia, Center for Health Research</p> <p>Pan, Tianxin; The University of Melbourne, Center for Health Policy, School of Population and Global Health</p> <p>Ishida, Marie; The University of Melbourne, Nossal Institute for Global Health</p> <p>Lee, John; The University of Melbourne, Nossal Institute for Global Health; Imperial College London, Department of Primary Care and Public Health, School of Public Health</p>
Keywords:	PUBLIC HEALTH, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health economics < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3 1 **Impact of multimorbidity on health service use, catastrophic health**
4 **expenditure, and productivity loss in Indonesia: a population-based**
5 **panel data analysis study**
6
7
8
9 4

10
11 5 Tiara Marthias[†], Kanya Anindya^{†*}, Nawi Ng, Barbara McPake, Rifat Atun, Hafiz
12
13 6 Arfyanto, Emily S G Hulse, Yang Zhao, Hafizah Jusril, Tianxin Pan, Marie Ishida,
14
15 7 John Tayu Lee
16
17
18
19 8

20
21 9 [†] Co-first author (both contributed equally)
22

23 10 * Corresponding author
24

25 11 Postal address: The Nossal Institute for Global Health, level 5, 333 Exhibition Street,
26
27 12 Melbourne, Victoria 3010 Australia.
28

29
30 13 E-mail address: kanindya@student.unimelb.edu.au
31

32 14 Telephone number: +62 878 9966 9201
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54

55 24 **Word count**
56

57 25 Main text: 4081
58

59 26 Abstract: 279
60

1
2
3 27 **Abstract**
4

5 28 **Objectives** To examine multimorbidity levels, and their relation to households'
6
7 socioeconomic characteristics, health service use, catastrophic health expenditures,
8
9 and productivity loss.
10
11

12 31
13
14 32 **Design** This observational study utilised a panel data of the Indonesian Family Life
15
16 Survey (IFLS) conducted in 2007 (Wave 4) and 2014 (Wave 5).
17
18
19 34

20
21 35 **Setting** The original sampling frame was based on 13 out of 27 provinces in 1993,
22
23 representing 83% of the population in Indonesia.
24
25

26 37
27
28 38 **Participants** We included respondents aged 50 years and above in 2007, excluding
29
30 those who did not participate in both Waves 4 and 5. Total participants in this study are
31
32 3,678 respondents.
33
34

35 41
36
37 42 **Primary outcome measures** This study examined three main outcomes; health service
38
39 use (outpatient and inpatient care), financial burden (catastrophic health expenditure),
40
41 and productivity loss (labour participation, days primary activity missed, days stayed
42
43 in bed).
44
45

46 46
47
48 47 **Results** Multimorbidity increased with sex, higher economic status, and higher
49
50 education attainment. Multimorbidity was associated with a substantially higher
51
52 number of outpatient visits (compared with those without NCDs, incidence rate ratio
53
54 [IRR] 4.30, 95% CI 3.37–5.47 for individuals with three or more NCDs), a higher
55
56 number of hospital visits (IRR 5.76, 95% CI 3.11–10.66 for individuals with three or
57
58
59
60

1
2
3 52 more NCDs). Multimorbidity was also associated with a greater likelihood of
4
5 53 experiencing catastrophic health expenditure (for three or more NCDs, adjusted odds
6
7 54 ratio [aOR] 1.68, 95% CI 0.13–2.52) and a lower participation in labour force (for three
8
9 55 or more NCDs, aOR 0.18, 95% CI 0.10–0.34) compared to those without NCDs.
10
11
12
13

14
15
16
17
18
19
20
21
22 56

23
24 57 **Conclusions** Multimorbidity is associated with substantial direct and indirect costs to
25
26 58 individuals, households, and the wider society. Our study highlights the importance of
27
28 59 preparing health systems for addressing the burden of multimorbidity in LMICs.
29
30
31
32

33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

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.

63

64 Introduction

65 Noncommunicable diseases (NCDs) continues to be the main cause of global burden
66 of diseases, with 78% of NCD-related mortality concentrated in low-income and
67 middle-income countries (LMICs).¹ Current COVID-19 global pandemic proves that
68 the presence of NCDs can also increase fatality risk of a communicable disease.² In
69 Indonesia, the third most populous country among LMICs (after China and India) with
70 a population of 273 million, has seen rapid demographic and epidemiological
71 transitions over the last few decades. The threat of NCDs is expected to rise with the
72 aging population, or population aged 65 or above, that is projected to account for a
73 quarter of the population by 2070.³ Concurrently, the prevalence of multimorbidity,
74 defined as the presence of two or more NCDs, is expected to rise rapidly in many
75 LMICs as life expectancy with exposure to risk factors increase.⁴ Indonesia has started
76 recognizing NCDs burden for its substantial contribution to the top causes of death and
77 disability-adjusted life years (DALYs).⁵ NCDs are now on one of targets on 2020–2024
78 National Medium-Term Development Plan and warrant one of key considerations on
79 national health account.⁶ However, current health programs remain limited to the

1
2
3 80 curative services focusing on single chronic disease as oppose to focusing on assessing
4
5 81 and mitigating the impact of multimorbidity on individual, health system and wider
6
7 82 society.
8
9

10 83
11
12 84 Current COVID-19 pandemic supplies hard evidence on the importance of strong
13
14 85 health system to better respond multimorbidity. Historically, the growing burden of
15
16 86 multimorbidity for health systems in LMICs were highlighted in the United Nations
17
18 87 High-Level Meetings on NCDs in 2011, 2014, and 2018.⁷ LMICs typically have low
19
20 88 levels of government expenditure for health and inadequate health insurance coverage.
21
22 89 This very often results in high levels of out-of-pocket expenditure (OOPE) and risk of
23
24 90 impoverishing health care spending for patients with long-term health conditions.^{8,9}
25
26 91 The economic burden multimorbidity is further compounded by the fact that
27
28 92 multimorbid patients are typically managed by multiple healthcare specialists in
29
30 93 LMICs.¹⁰ This leads to inefficiencies with numerous different hospital visits,
31
32 94 polypharmacy, and suboptimal disease management.^{10,11}
33
34
35
36
37
38
39

40 96 Evidence from high-income countries (HICs) has found that apart from the negative
41
42 97 impact on health outcomes, multimorbidity imposes substantial economic costs on
43
44 98 individuals and households as patients with multimorbidity incur large medical
45
46 99 expenditures and are more likely to be absent from work.^{9,12,13} To the best of our
47
48 100 knowledge, there is no study in Indonesia that has have examined the economic burden
49
50 101 of multimorbidity, as earlier studies have focused on the burden of a single NCD (such
51
52 102 as cardiovascular disease and diabetes).¹⁴ As Indonesia constitute a vast and diverse
53
54 103 population and has the most diverse set of topologies and economic conditions, our
55
56 104 study may contribute to inform health systems reform across the region and beyond.
57
58
59
60

1
2
3 105 We present the first study that uses longitudinal data to examine multimorbidity levels,
4
5 106 and their relation to households' socioeconomic characteristics, health service use,
6
7 107 catastrophic health expenditures, and productivity loss. Our findings on multimorbidity
8
9 108 will support decision makers on the measures towards a more efficient and strengthen
10
11 109 health system in Indonesia.
12
13
14
15

110

111 **Methods**

112 **Sample and data**

113 The study used panel data from two waves of the Indonesian Family Life Survey (IFLS)
114 conducted in 2007 (Wave 4) and 2014 (Wave 5). IFLS is an ongoing longitudinal
115 survey that started in 1993 with four subsequent rounds of data collection (1997/1998,
116 2000, 2007/2008, and 2014). The original sampling frame was based on 13 out of 27
117 provinces in 1993, representing 83% of the population. Wave 5 was conducted between
118 September 2014–March 2015, with 76% re-contact rate from the Wave 1 main
119 respondents. The dataset contains individuals' and their household information,
120 including sociodemographic characteristics, healthcare utilisation, health expenditure,
121 and employment participation. The survey objectives and methods are detailed
122 elsewhere.^{15,16} In our analysis, we included respondents aged 50 years and above in
123 2007, excluding those who did not participate in both Waves 4 and 5, and those with
124 missing values for the study variable. Our final sample is 3,678 respondents (sample
125 flowchart is presented in Figure S1). We report this study according to the
126 Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)
127 guidelines (Table S1)

128

1
2
3 129 **Variables**
4
5

6 130 *Multimorbidity*
7

8 131 Our main variable of interest was multimorbidity. The number of NCDs that was
9
10 132 included in Wave 5 was 14, but it was only 10 NCDs in Wave 4. For consistency, our
11
12 133 main analysis used 10 NCDs that were available in both waves. The 10 NCDs that were
13
14 134 consistently measured were the following: hypertension, diabetes, asthma, heart
15
16 135 attack/coronary heart diseases, liver disease, stroke, cancer, arthritis/rheumatism,
17
18 136 hypercholesterolemia, and depression/mental illness. The four NCDs that were only
19
20 137 included in Wave 4 were: prostate diseases, kidney diseases (excluding malignancy),
21
22 138 digestive diseases, and memory-related diseases.
23
24
25
26
27
28

29 139

30 140 NCD status was either identified through self-reporting or physical examination. In the
31
32 141 self-report section, respondents who answered affirmatively to the question, “Has a
33
34 142 doctor/paramedic/nurse/midwife ever told you that you had any of these conditions?”,
35
36 143 were defined as reporting an NCD. For hypertension and hypercholesterolemia, the
37
38 144 diagnoses were confirmed through physical examination conducted by trained nurses,
39
40 145 i.e. blood pressure and total cholesterol levels. All IFLS respondents aged 15 years and
41
42 146 older had their blood pressure recorded three times on alternate arms using Omron self-
43
44 147 inflating sphygmomanometers by trained nurses.^{15,16} In our analysis, a respondent was
45
46 148 categorised as having hypertension if the mean measurement of systolic blood pressure
47
48 149 was ≥ 140 mm Hg and/or mean diastolic blood pressure was ≥ 90 mm Hg or the
49
50 150 respondent self-reported having been diagnosed with hypertension.¹⁷ We also included
51
52 151 hypercholesterolemia, defined as total blood cholesterol value ≥ 240 mg/dl, as
53
54 152 morbidity.¹⁸ It is important to note that different measurements of hypercholesterolemia
55
56
57
58
59
60

1
2
3 153 were used in Wave 4 and 5. Blood test for total cholesterol was performed in Wave 4
4
5 154 as opposed to self-reporting of hypercholesterolemia in Wave 5.
6
7
8
9 155

10
11 156 For our analyses, a total of 10 NCDs were used to quantify the number of NCDs (0, 1,
12
13 157 2, 3 or more) and respondents with two or more NCDs were categorised as having
14
15 158 multimorbidity (categorised as 0 or 1). Previous studies have typically considered
16
17 159 hypertension, obesity, and hypercholesterolemia as risk factors of NCDs and their
18
19 160 inclusion in the multimorbidity clustering remains inconsistent.^{4,13} Therefore, in the
20
21 161 sensitivity analysis, we included obesity, defined as having BMI ≥ 25 kg/m², in the
22
23 162 clustering of multimorbidity (Table S10–12).¹⁹ All statistical analyses were conducted
24
25 163 using STATA 13.0.
26
27
28
29
30 164

31 32 165 ***Outcome variables***

33
34 166 This study examined three main outcomes; health service use and financial burden as
35
36 167 the direct cost and; productivity loss as the indirect cost of multimorbidity. Respondents
37
38 168 were asked about the number of outpatient visits (in the last four weeks) and inpatient
39
40 169 visits (in the last 12 months) and out-of-pocket expenditure (OOPE). The data on OOPE
41
42 170 was also collected with four weeks recall period for outpatient visits and 12 months
43
44 171 recall period for inpatient visits (in the past year). We calculated the total annual OOPE
45
46 172 by multiplying OOPE for outpatient visits with 13 (as the reference period of outpatient
47
48 173 expenditure in the IFLS is four weeks and a year consists of 52 weeks), and added
49
50 174 OOPE for inpatient visits.
51
52
53
54

55 175

56
57 176 Catastrophic health expenditure occurs when OOP spending on health services exceed
58
59 177 certain proportions of a household's expenditure. The proportions, or thresholds, used

1
2
3 178 in this study were 10% and 25% of total household expenditure (as proposed the
4
5 179 Sustainable Development Goal 3 (SDGs) targets), and the WHO's recommendation at
6
7 180 40% of household's capacity to pay. Capacity to pay is defined as the household's
8
9 181 capacity to pay for other expenses, including medical costs, after having household
10
11 182 subsistence needs met.²⁰ Household subsistence needs are proxied by the household
12
13 183 non-food expenditure variable. Catastrophic health expenditure ($cata_h$) occurrence is
14
15 184 expressed as follows:

16
17
18
19
20 185
$$cata_h = 1 \text{ if } \frac{HS_h}{THE_h} \text{ or } \frac{HS_h}{CTP_h} > z, \text{ and otherwise is zero.}$$

21
22
23 186 Where HS_h is the total OOPE for health, THE_h is the total household expenditure, CTP_h
24
25 187 is capacity to pay, and z is given thresholds. All monetary values were adjusted for
26
27 188 inflation and converted to 2014 International Dollars.²¹

28
29 189
30
31
32 190 Productivity loss was assessed based on three variables: (1) labour participation; (2) the
33
34 191 number of days of primary activity missed due to poor health; and (3) number of days
35
36 192 confined to bed. Labour participation status was defined as the respondent's
37
38 193 employment status at the time of the survey. The number of days of primary daily
39
40 194 activity missed and days confined to bed were included in the health conditions section
41
42 195 of the survey with four weeks recall period.

43 196 **Covariates**

44
45
46 197 Sociodemographic factors included were: sex, age groups (50-60, 61-70, above 70
47
48 198 years), marital status (not currently married and currently married), education (no
49
50 199 education, primary, junior high school, senior high school, tertiary), ethnicity
51
52 200 (Javanese, Sundanese, others), coverage of health insurance (no, yes), type of work
53
54 201 (unemployed, casual, self-employed, government/private), and respondents' economic
55
56 202 status (per capita expenditure for consumption). The economic status was categorized

1
2
3 203 into quintiles: q1 (lowest) to q5 (highest). We also included residency (rural, urban),
4
5 204 region of residency (Java-Bali, Sumatra, Nusa Tenggara, Kalimantan, Sulawesi), and
6
7
8 205 period (using wave 2007 as the reference group) as covariates. Detailed definitions and
9
10 206 categorisations are available in (Table S2). It should be noted that IFLS did not include
11
12 207 the eastern regions, Papua and Papua Barat, which are considered to be
13
14
15 208 underdeveloped.

16
17 209

18 19 210 **Statistical analysis**

20
21
22 211 We described the patterns of multimorbidity across different population subgroups and
23
24 212 presented the weighted percentages with 95% confidence interval (CI). Taking into
25
26 213 account the hierarchical (nested) nature of the dataset (i.e. observations nested within
27
28 214 individuals, and individuals nested within households, and districts),²² a multilevel
29
30 215 level model approach was used to examine factors associated with multimorbidity and
31
32 216 its relation to the outcome variables. Multilevel negative binomial regression models
33
34 217 were performed to examine the association between multimorbidity and the numbers
35
36 218 of outpatient visits and days in the hospital. We used negative binomial models instead
37
38 219 of Poisson models due to over-dispersion of the count data variable. We applied
39
40 220 multilevel logistic regression models to observe binary outcome variables and
41
42 221 calculated the intra-class correlation coefficients (ICC). The multilevel analyses were
43
44 222 conducted using unweighted data as our aim was on testing the association between
45
46 223 multimorbidity and the outcomes and examine the mixed effects, rather than deriving
47
48 224 nationally representative estimates.²³ We also conducted a robustness check to
49
50 225 investigate the association between multimorbidity and costs using the 2014 cross-
51
52 226 sectional dataset, that contains information for four additional NCDs than the 2007
53
54
55
56
57
58
59 227 Wave.
60

228 Patient and public involvement

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

231 Results

232 Descriptive statistics

233 Our total sample size was 3,678 respondents. Table 1 presents the respondents'
234 characteristics by multimorbidity status in 2007 and 2014. The median age in 2007 was
235 58 years (IQR 54–65), 53.9% [95% CI were female, 74.4% were married, 16.5% had
236 at least secondary level or above education, just 25.5% had health insurance coverage,
237 and 77.5% live in Java-Bali region. In 2014, the median age was 65 years (IQR 60–72),
238 and health insurance coverage increased to 42.8%.

239 << insert Table 1>>

240 Overall, the prevalence of multimorbidity increased from 21.0% (95% CI 19.6–22.6)
241 in 2007 to 22.0% (95% CI 20.6–23.6) in 2014. The prevalence of multimorbidity
242 increased with rising socioeconomic status. For example, in 2014, the prevalence was
243 18.0% (CI 16.9–20.7) in respondents with no education compared to 41.2% (95% CI
244 31.6–51.6) in those with tertiary education. Similarly, the prevalence increased from
245 13.5% (95% CI 11.1–16.2) to 36.2% (95% CI 32.2–40.5) between the lowest and
246 highest wealth quintiles. The trend of increasing multimorbidity was observed for all
247 age groups, shown in Fig 1, where the fifth and fourth household expenditure quintiles
248 had a higher prevalence of multimorbidity than lower quintiles.

249 << insert Figure 1>>

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

1
2
3 253 multimorbidity, compared with those in the lowest household expenditure quintile
4
5 254 (aOR 2.22, 95% CI 1.72–2.86). In comparison with those with lower educational
6
7
8 255 attainment, respondents with higher educational attainment were more likely to
9
10 256 experience multimorbidity (aOR 1.54, 95% CI 1.01–2.34 for tertiary level completed).
11
12 257 Additionally, the prevalence of multimorbidity was higher in females than males (aOR
13
14 258 1.74, 95% CI 1.46–2.08) and those living in urban areas (aOR 1.41, 95% CI 1.19–1.67).
15
16
17 259 The ICC shows that above 53% (1-[0.34+0.13]) of the variance can be ascribed to
18
19 260 between-individual level differences (Table S4).
20
21
22 261

262 **Multimorbidity and health service use**

263 People with multimorbidity had a higher rate of outpatient and inpatient visits (Table
264 2). In 2014, the proportion of outpatient visits among respondents with three or more
265 NCDs (55.9% [95% CI 49.0–62.6]) was greater than those without NCDs (15.5% [95%
266 CI 13.3–17.9]). Similarly, for inpatient visits, only 3.3% (95% CI 2.3–4.8) of those
267 without NCD used inpatient service within one year of the survey compared to 20.8%
268 (95% CI 15.7–27.0) among those with three or more NCDs.

269 << insert Table 2 >>

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

1
2
3 278 incidence of inpatient visits was 3.68 times (95% CI 2.21–6.12) higher in those with
4
5 279 three or more NCDs, compared to those without an NCD.
6
7
8 280

9
10 281 We reported the results of ICC in Table S4. We found that 14% and 11% of the variance
11
12 282 in the outpatient visit were attributable to the differences within-individual and
13
14 283 households, respectively. Between-individual variation accounted for the largest
15
16 284 variation, where it explained 75% (1-[0.14+0.11]) and 65% (1-[0.25+0.12]) of
17
18 285 outpatient and inpatient visit, respectively. No influence of district-level variables was
19
20 286 shown (ICC=0).
21
22
23

24 287 << insert Table 3 >>

26 288 **Multimorbidity and financial burden**

27
28 289 The mean OOPE for outpatient care incurred by respondents during the last four weeks
29
30 290 increased from INT\$17 in those without any NCDs to \$60 in those with three or more
31
32 291 NCDs in 2014 (Table 2). Similarly, for inpatient visits, having three or more NCDs
33
34 292 resulted in higher mean OOPE of \$762 (SD ± \$1,421) compared to \$566 (SD ± \$1,880)
35
36 293 for those without any NCDs. Total annual OOPE also increased from \$295 (SD ± \$977)
37
38 294 among those without any NCDs to \$968 (SD ± \$4,313) among those with three or more
39
40 295 NCDs. Table 2 also presents the proportion of respondents with catastrophic health
41
42 296 expenditure using different household budget thresholds. At 10% of total household
43
44 297 expenditure threshold, 5.0% (95% CI 3.7–6.6) of households without any member
45
46 298 having any NCDs experienced catastrophic health expenditure compared to 12.5%
47
48 299 (95% CI 8.7–17.7) of households with a member/s diagnosed with three or more NCDs.
49
50
51 300 The results using 25% of total household expenditure and 40% of non-food
52
53 301 consumption thresholds also suggest that households with a member/s diagnosed with
54
55
56
57
58
59
60

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

304

305 Table 4 presents the logistic regression results for the proportion of respondents who
306 experienced catastrophic health expenditure, using both total household expenditure
307 and non-food expenditure thresholds. At 10% of total household expenditure as the
308 threshold, having two NCDs increases the odds of catastrophic health expenditure to
309 1.58 times (95% CI 1.06–2.35), compared to having none. These odds increased to 1.69
310 times for those having three NCDs or more (95% CI 1.02–2.81). At 25% and 40%
311 thresholds, we found no significant association between the number of NCD diagnoses
312 and the incidence of catastrophic health expenditure.

313 << insert Table 4 >>

314 **Multimorbidity and productivity loss**

315 More NCDs diagnoses was associated with greater productivity loss (Table 2, Table 5).
316 For example, among those aged 50–60 years old, only 49.8% (CI 36.7–62.9) of
317 respondents with three or more NCDs were employed, compared with 84.3% (CI 79.8–
318 88.0) of respondents without NCDs (Table 2). The mean number of days of primary
319 daily activity missed increased substantially from 2.7 days (SD ± 6.0), for those without
320 any NCDs, to 10.1 days (SD ± 12.1) for those with three or more NCDs. The mean
321 number of days confined to bed also increased from 0.80 days (SD ± 3.4), for those
322 without any NCD, to 2.4 days (SD ± 6.3) for those with three or more NCDs.

323

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

327 more) were expected to have a higher incidence rate of missing days of primary activity
328 (IRR 2.59, 95% CI 1.97–3.41) as well as days spent in bed (IRR 2.64, 95% CI 1.60–
329 4.36). We found that 48% of the variance in the labour participation was due to within-
330 individual variations, while between-individual variation accounted for 23% (1-
331 [0.48+0.28+0.01]) (Table S4).

332 << insert Table 5>>

333 **Robustness check**

334 Our robustness analysis using cross-sectional analysis using 2014 cross-sectional
335 dataset that consists of 14 physical NCDs (Table S5-8) showed consistent results with
336 our original findings. Higher household expenditure (aOR 2.03, 95% CI 1.65–2.50 for
337 the highest quintile, compared with the lowest quintile and education status) and higher
338 education (aOR 1.77, 95% CI 1.33–2.36 for tertiary level completed, compared with
339 those with no formal education) were associated with greater burden of multimorbidity.
340 Also, in line with our original findings, multimorbidity was associated with higher
341 health care use, higher incidence of catastrophic health expenditures, and lower
342 productivity. The association between multimorbidity and catastrophic health
343 expenditure was more pronounced in the cross-sectional analysis.

344

345 **Discussion**

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

1
2
3 351 surveys). Multimorbidity was associated with higher use of healthcare services, higher
4
5 352 probability of catastrophic health expenditure, and a reduction in productivity.
6
7
8 353

9
10 354 Analyses of socioeconomic gradients of NCDs in HICs routinely find negative
11
12 355 socioeconomic gradients. However, this is not the case for LMICs, which have a more
13
14 356 mixed pattern of the distribution of risk factors.^{24,25} Other studies find a similar picture
15
16 357 with diabetes and cardiovascular diseases in LMICs undergoing epidemiological
17
18 358 transition.²⁵ These conditions predominate in high-income quintiles in early stages of
19
20 359 transition. However, our results on socioeconomic patterning of multimorbidity can
21
22 360 also be explained by the fact that higher-income and higher-educational groups, who
23
24 361 have better access to healthcare services and better health literacy, are more likely to
25
26 362 have NCDs diagnosed (or even over-diagnosed) than lower socio-income groups.
27
28
29
30

31
32 363

33
34
35 364 Our findings that show having more NCDs is associated with greater use of outpatient
36
37 365 and inpatient services is in line with earlier studies from both HICs and LMICs.^{4,10,26}
38
39 366 The presence of multimorbidity was also associated with a greater financial burden, as
40
41 367 measured by catastrophic health expenditures, which is mainly driven by higher
42
43 368 healthcare use; these findings are consistent with earlier studies.^{4,11,26,27} Based on a
44
45 369 previous Indonesian study, four NCDs (hypertension, diabetes, heart problems, and
46
47 370 stroke) are the leading causes of mortality, and were estimated to account for 12% of
48
49 371 Indonesia's OOPE in 2020.¹³ Furthermore, impoverishment effect of multimorbidity
50
51 372 has been previously documented and is confirmed in our study.^{8,9,12,13}
52
53
54
55

56 373

57
58 374 This study contributes to the growing evidence that multimorbidity has a substantial
59
60 375 impact on disability and employment productivity.^{8,10,13} Interventions that can help

1
2
3 376 effectively manage multimorbidity have the potential for generating substantial returns
4
5 377 on improved health, work productivity and social benefits. Therefore, strategies aimed
6
7 378 at addressing multimorbidity can be considered as an ‘investment’ rather than a cost,
8
9 379 with the costs of the interventions largely ‘offset’ by long-term cost savings achieved
10
11 380 from improved health and productivity.²⁸
12
13
14

15 381

16
17 382 This study provides the first evidence to inform policies and the development of
18
19 383 targeted strategies for multimorbidity in Indonesia, where preventive and promotive
20
21 384 services against NCDs are inadequate and a large portion of government health
22
23 385 expenditure is still geared towards curative care.⁵ Renewing focus on health promotion
24
25 386 and NCD prevention requires a strong primary health care (PHC) system.¹⁰ PHC is the
26
27 387 entry point of a sustainable health system for the early detection of risk factors and
28
29 388 initiation of treatment-seeking pathway for patients with NCDs, and thus, plays a
30
31 389 crucial role for NCD prevention and provision of long-term integrated care. Such
32
33 390 policies would be in line with the current program of the Ministry of Health in Indonesia
34
35 391 to reorient public PHC to provide more promotive and preventive health services, such
36
37 392 as through the implementation of Chronic Diseases Management Program (Prolanis) in
38
39 393 PHC.^{29,30} However, the participation to this program remains low due to the poor access
40
41 394 to PHC facilities, especially in outside Java region. There is a need to engage private
42
43 395 sector, which makes up 60% of health facilities in Indonesia, to expand the coverage of
44
45 396 NCD promotive and prevention activities.³¹ Furthermore, the development of digital
46
47 397 health solution for NCDs prevention and control should be included in the national
48
49 398 COVID-19 plan.³²
50
51
52
53
54
55

56 399
57
58
59
60

1
2
3 400 Worldwide, disease-specific clinical guidelines are inadequate for the effective
4
5 401 management of individuals with multimorbidity.^{10,33} Although most countries and
6
7 402 international health organizations have recognized the importance of multimorbidity
8
9 403 (30), most health policies and programs still focus on single diseases. In Indonesia,
10
11 404 current clinical practices and public health intervention largely focus on a single-
12
13 405 disease framework. For example, Indonesia currently has no official clinical guideline
14
15 406 to manage multimorbidity. Furthermore, under the current national health insurance
16
17 407 scheme, the hospital reimbursement system that uses case-based groups has created
18
19 408 significant gaps between reimbursable costs and actual hospital expenses.³⁴ The
20
21 409 reimbursement system, which is mainly based on primary diagnosis, limits the
22
23 410 hospital's capacity and willingness to treat complicated cases such as those with
24
25 411 multimorbidity.³⁵ Thus, it is important to develop a clinical guideline for
26
27 412 multimorbidity in Indonesia and other LMICs, along with payment systems that would
28
29 413 ensure quality health services at both primary and secondary levels of care for patients
30
31 414 with multimorbidity.
32
33
34
35
36
37
38
39
40
41

416 There are several limitations to our study. First, the IFLS-5 was conducted between
417 2014 and 2015, which may not able to capture current prevalence of multimorbidity in
418 Indonesia. Despite this limitation, IFLS is the only longitudinal survey available in
419 Indonesia that is useful to produce more accurate estimates compared with using cross-
420 sectional dataset (e.g. the National Socioeconomic Survey). Second, our findings
421 should be interpreted with causation since the assessment of chronic diseases was
422 mostly based on self-reporting and may cause under-reporting of the prevalence. The
423 health service use and OOP spending were also based on self-reporting and prone to
424 recall bias.³⁶ Third, the IFLS sampling frame did not include Eastern regions of

1
2
3 425 Indonesia. There is a need to extend the multimorbidity assessment to the remaining
4
5 426 Indonesian regions. Fourth, this research intentionally focused on the older population
6
7 427 due to a significantly higher burden of NCDs in this population group. Future research
8
9 428 should use cohort data to follow patients over a longer time period to examine the
10
11 429 impact of multimorbidity and its effects in younger population groups in LMICs.¹³
12
13
14
15
16

17 430

17 431 **Conclusion**

18
19 432 Multimorbidity poses substantial costs to individuals, households, health system and
20
21 433 the wider society in Indonesia, which has an increasingly aging population.
22
23 434 Policymakers and employers in Indonesia should carefully design and invest in targeted
24
25 435 public health and workplace interventions at personal and population level to avert the
26
27 436 adverse health and economic consequences of multimorbidity.
28
29
30

31 437

32 438 **Declarations**

33 439 **Abbreviation**

34
35 440 CHE: Catastrophic health expenditure; HICs: High-income countries; IFLS: Indonesian Family Life
36
37 441 Survey; LMICs: Low-middle income countries; NCDs: Noncommunicable diseases; OOPE: Out-
38
39 442 of-pocket expenditure; PHC: Primary health care.
40
41

42 443 **Competing interests**

43
44 444 The authors have declared that no competing interests exist.
45

46 445 **Ethics approval**

47
48 446 The IFLS has been approved by ethics review boards at RAND Corporation and Gadjah Mada
49
50 447 University in Indonesia. Written informed consent was sought from all respondents prior to data
51
52 448 collection.
53

54 449 **Author's contributions**

55
56 450 Author's contributions: The aim of the research was developed by TM, KA, JL. The methodology
57
58 451 development and analysis were conducted by TM, KA, HA, TP, JL. EH assisted in drafting the
59
60

1
2
3 452 discussion section and proofread all section. YZ, HJ, MI contributed to background and discussion
4
5 453 section. NN, BM, RA, JL provided critical input in revising the manuscript. All authors reviewed,
6
7 454 edited and commented on multiple versions of the manuscript.
8

9 455 **Author details**

10 456 ¹Nossal Institute for Global Health, The University of Melbourne, Melbourne, Australia

11 457 ²Department of Public Health, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah

12 458 Mada, Yogyakarta, Indonesia ³Department of Public Health and Community Medicine, University

13 459 of Gothenburg, Sweden ⁴Department of Global Health and Population, Harvard T.H. Chan School

14 460 of Public Health, Harvard University, Boston, MA, USA ⁵SMeRU Research Institute, Jakarta,

15 461 Indonesia ⁶School of Population and Global Health, The University of Melbourne, Melbourne,

16 462 Australia ⁷Center for Health Research, Faculty of Public Health, Universitas Indonesia, Depok,

17 463 Indonesia ⁸Center for Health Policy, School of Population and Global Health, The University of

18 464 Melbourne, Melbourne, Australia ⁹Department of Primary Care and Public Health, School of Public

19 465 Health, Imperial College London, United Kingdom

20 466 **Availability of data and materials**

21 467 The datasets are publicly accessible after registration ([https://www.rand.org/well-being/social-and-](https://www.rand.org/well-being/social-and-behavioral-policy/data/FLS/IFLS/access.html)

22 468 [behavioral-policy/data/FLS/IFLS/access.html](https://www.rand.org/well-being/social-and-behavioral-policy/data/FLS/IFLS/access.html)).

23 469 **Acknowledgements**

24 470 The authors of the paper express sincere gratitude to the RAND for providing access to the data.

25 471 We acknowledge Nur Arna Sucianti from SurveyMeter, for guiding us with data merging.

26 472 **Funding**

27 473 This research received no specific grant from any funding agency in the public, commercial or

28 474 not-for-profit sectors

475 **References**

- 476 1. WHO. *Noncommunicable diseases country profiles 2018*. Geneva: World
477 Health Organization, [https://www.who.int/nmh/publications/ncd-profiles-](https://www.who.int/nmh/publications/ncd-profiles-2018/en/)
478 [2018/en/](https://www.who.int/nmh/publications/ncd-profiles-2018/en/) (2018).
- 479 2. Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of
480 adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study.
481 *Lancet* 2020; 395: 1054–1062.
- 482 3. United Nations, Department of Economic and Social Affairs PD. World
483 population prospects 2019, online edition. Rev. 1.,
484 <https://population.un.org/wpp/Download/Standard/Population/> ((2019,
485 accessed 8 March 2020).
- 486 4. Hussain MA, Huxley RR, Al Mamun A. Multimorbidity prevalence and pattern
487 in Indonesian adults: An exploratory study using national survey data. *BMJ*
488 *Open* 2015; 5: e009810.
- 489 5. Mboi N, Murty Surbakti I, Trihandini I, et al. On the road to universal health
490 care in Indonesia, 1990–2016: a systematic analysis for the Global Burden of
491 Disease Study 2016. *Lancet* 2018; 392: 581–591.
- 492 6. Agustina R, Dartanto T, Sitompul R, et al. Universal health coverage in
493 Indonesia: concept, progress, and challenges. *Lancet* 2019; 393: 75–102.
- 494 7. United Nations. Political declaration of the third high-level meeting of the
495 General Assembly on the prevention and control of non-communicable
496 diseases, https://www.un.org/en/ga/search/view_doc.asp?symbol=A/RES/73/2
497 (2018, accessed 8 March 2020).
- 498 8. Sum G, Hone T, Atun R, et al. Multimorbidity and out-of-pocket expenditure
499 on medicines: a systematic review. *BMJ Glob Heal* 2018; 3: e000505.

- 1
2
3 500 9. Wang L, Si L, Cocker F, et al. A systematic review of cost-of-illness studies of
4
5 501 multimorbidity. *Applied Health Economics and Health Policy* 2018; 16: 15–29.
6
7
8 502 10. Barnett K, Mercer SW, Norbury M, et al. Epidemiology of multimorbidity and
9
10 503 implications for health care, research, and medical education: a cross-sectional
11
12 504 study. *Lancet (London, England)* 2012; 380: 37–43.
13
14
15 505 11. Salisbury C. Multimorbidity: redesigning health care for people who use it.
16
17 506 *Lancet (London, England)* 2012; 380: 7–9.
18
19 507 12. Jaspers L, Colpani V, Chaker L, et al. The global impact of non-communicable
20
21 508 diseases on households and impoverishment: a systematic review. *European*
22
23 509 *Journal of Epidemiology* 2014; 30: 163–188.
24
25
26 510 13. Lee JT, Hamid F, Pati S, et al. Impact of Noncommunicable Disease
27
28 511 Multimorbidity on Healthcare Utilisation and Out-Of-Pocket Expenditures in
29
30 512 Middle-Income Countries: Cross Sectional Analysis. *PLoS One* 2015; 10:
31
32 513 e0127199.
33
34
35 514 14. Finkelstein EA, Chay J, Bajpai S. The Economic Burden of Self-Reported and
36
37 515 Undiagnosed Cardiovascular Diseases and Diabetes on Indonesian Households.
38
39 516 *PLoS One* 2014; 9: e99572.
40
41
42 517 15. Strauss J, Witoelar F, Sikoki B. *The fifth wave of Indonesia Family Life Survey:*
43
44 518 *Overview and Field Report*. Santa Monica, California, 2016.
45
46
47 519 16. Straus J, Witoelar F, Sikoki B, et al. *The fourth wave of the Indonesia Family*
48
49 520 *Life Survey: overview and field report*. 2019.
50
51
52 521 17. Chobanian A V., Bakris GL, Black HR, et al. The Seventh Report of the Joint
53
54 522 National Committee on Prevention, Detection, Evaluation, and Treatment of
55
56 523 High Blood Pressure: The JNC 7 Report. *Journal of the American Medical*
57
58 524 *Association* 2003; 289: 2560–2572.
59
60

- 1
2
3 525 18. Grundy SM, Cleeman JI, Bairey Merz CN, et al. Implications of recent clinical
4
5 526 trials for the National Cholesterol Education Program Adult Treatment Panel
6
7 527 III guidelines. *Circulation* 2004; 110: 227–239.
- 8
9 528 19. Pacific WHORO for the W. *The Asia-Pacific perspective : redefining obesity*
10
11 529 *and its treatment*. Sydney : Health Communications Australia,
12
13 530 <http://iris.wpro.who.int/handle/10665.1/5379>.
- 14
15 531 20. Xu K, Saksena P, Jowett M, et al. Exploring the thresholds of health
16
17 532 expenditure for protection against financial risk. *World Heal Rep* 2010;
18
19 533 Background: 328–333.
- 20
21 534 21. Organisation for Economic Co-operation and Development (OECD).
22
23 535 Purchasing power parities (PPP), [https://data.oecd.org/conversion/purchasing-](https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm)
24
25 536 [power-parities-ppp.htm](https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm) (2019, accessed 10 September 2019).
- 26
27 537 22. Vaezghasemi M, Ng N, Eriksson M, et al. Households, the omitted level in
28
29 538 contextual analysis: Disentangling the relative influence of households and
30
31 539 districts on the variation of BMI about two decades in Indonesia. *International*
32
33 540 *Journal for Equity in Health* 2016; 15: 102.
- 34
35 541 23. Lee ES, Forthofer RN. *Analyzing complex survey data*. Second edi. SAGE
36
37 542 Publications, 2006. Epub ahead of print 2006. DOI:
38
39 543 <https://dx.doi.org/10.4135/9781412983341>.
- 40
41 544 24. Hosseinpoor AR, Bergen N, Kunst A, et al. Socioeconomic inequalities in risk
42
43 545 factors for non communicable diseases in low-income and middle-income
44
45 546 countries: results from the World Health Survey. *BMC Public Health* 2012; 12:
46
47 547 912.
- 48
49 548 25. Manne-Goehler J, Atun R, Stokes A, et al. Diabetes diagnosis and care in sub-
50
51 549 Saharan Africa: pooled analysis of individual data from 12 countries. *lancet*
- 52
53
54
55
56
57
58
59
60

- 1
2
3 550 *Diabetes Endocrinol* 2016; 4: 903–912.
- 4
5 551 26. Wang HHX, Wang JJ, Wong SYS, et al. Epidemiology of multimorbidity in
6
7 552 China and implications for the healthcare system: cross-sectional survey among
8
9 553 162,464 community household residents in southern China. *BMC Med* 2014;
10
11 554 12: 188.
- 12
13 555 27. Mondor L, Maxwell CJ, Hogan DB, et al. Multimorbidity and healthcare
14
15 556 utilization among home care clients with dementia in Ontario, Canada: A
16
17 557 retrospective analysis of a population-based cohort. Epub ahead of print 2017.
18
19 558 DOI: 10.1371/journal.pmed.1002249.
- 20
21 559 28. Cancelliere C, Cassidy JD, Ammendolia C, et al. Are workplace health
22
23 560 promotion programs effective at improving presenteeism in workers? A
24
25 561 systematic review and best evidence synthesis of the literature. *BMC Public*
26
27 562 *Health*; 11. Epub ahead of print 2011. DOI: 10.1186/1471-2458-11-395.
- 28
29 563 29. Kemenkes akan memperkuat fungsi preventif dan promotif melalui akreditasi
30
31 564 puskesmas. *Kompas id*, 28 October 2019.
- 32
33 565 30. Gani A, Budiharsana M. *The consolidated report on Indonesia health sector*
34
35 566 *review 2018*. 2018.
- 36
37 567 31. Mahendradhata Y, Trisnantoro L, Listyadewi S, et al. The Republic of
38
39 568 Indonesia Health System Review. Asia Pacific Observatory on Health Systems
40
41 569 and Policies. *Health Syst Transit* 2017; 7: xxvi, 66.
- 42
43 570 32. World Health Organization. *Preliminary results: Rapid assessment of service*
44
45 571 *delivery noncommunicable diseases (NCDs) during the COVID-19 pandemic*.
46
47 572 2020.
- 48
49 573 33. Hoffmann T, Jansen J, Glasziou P. The importance and challenges of shared
50
51 574 decision making in older people with multimorbidity. Epub ahead of print

- 1
2
3 575 2018. DOI: 10.1371/journal.pmed.1002530.
4
5 576 34. Satibi S, Andayani TM, Endarti D, et al. Comparison of real cost versus the
6
7 577 indonesian case base groups (INA-CBGs) tariff rates among patients of high-
8
9 578 incidence cancers under the national health insurance scheme. *Asian Pac J*
10
11 579 *Cancer Prev* 2019; 20: 117–122.
12
13 580 35. Schröders J, Wall S, Hakimi M, et al. How is Indonesia coping with its
14
15 581 epidemic of chronic noncommunicable diseases? A systematic review with
16
17 582 meta-analysis. *PLoS One* 2017; 12: e0179186.
18
19 583 36. Vellakkal S, Subramanian S V, Millett C, et al. Socioeconomic Inequalities in
20
21 584 Non-Communicable Diseases Prevalence in India: Disparities between Self-
22
23 585 Reported Diagnoses and Standardized Measures. *PLoS One* 2013; 8: e68219.
24
25 586
26
27
28
29
30
31 587
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

588 **Tables & Figures**

589

590 **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

591

592

593 **Table 2. Descriptive summary of health service use-financial burden and**
 594 **productivity outcomes by number of NCDs (2014 IFLS)**
 595

	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				
<i>Outpatient services</i> ^{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
<i>Inpatient services</i> ^{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
<i>Catastrophic health expenditure (%; 95% CI)</i>				
>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% (0.6–2.5)	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				
<i>Labour participation (%; 95% CI)</i>				
50-60 years ^{d)}	84.3% (79.8–88.0)	74.3% (69.3–78.8)	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.

596

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

598

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 disease

601 **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

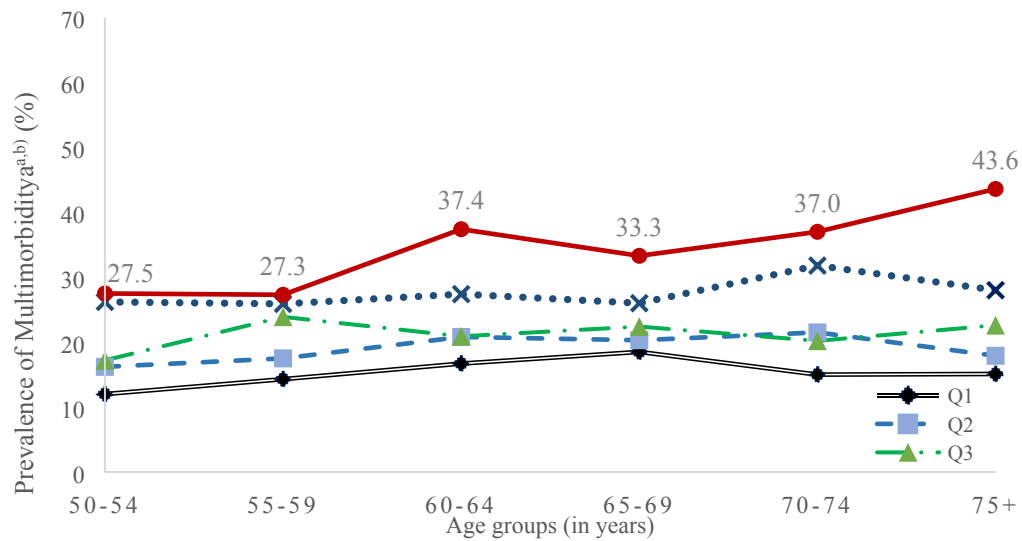
a) Multilevel logistic regression model

b) Multilevel negative binomial regression model

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

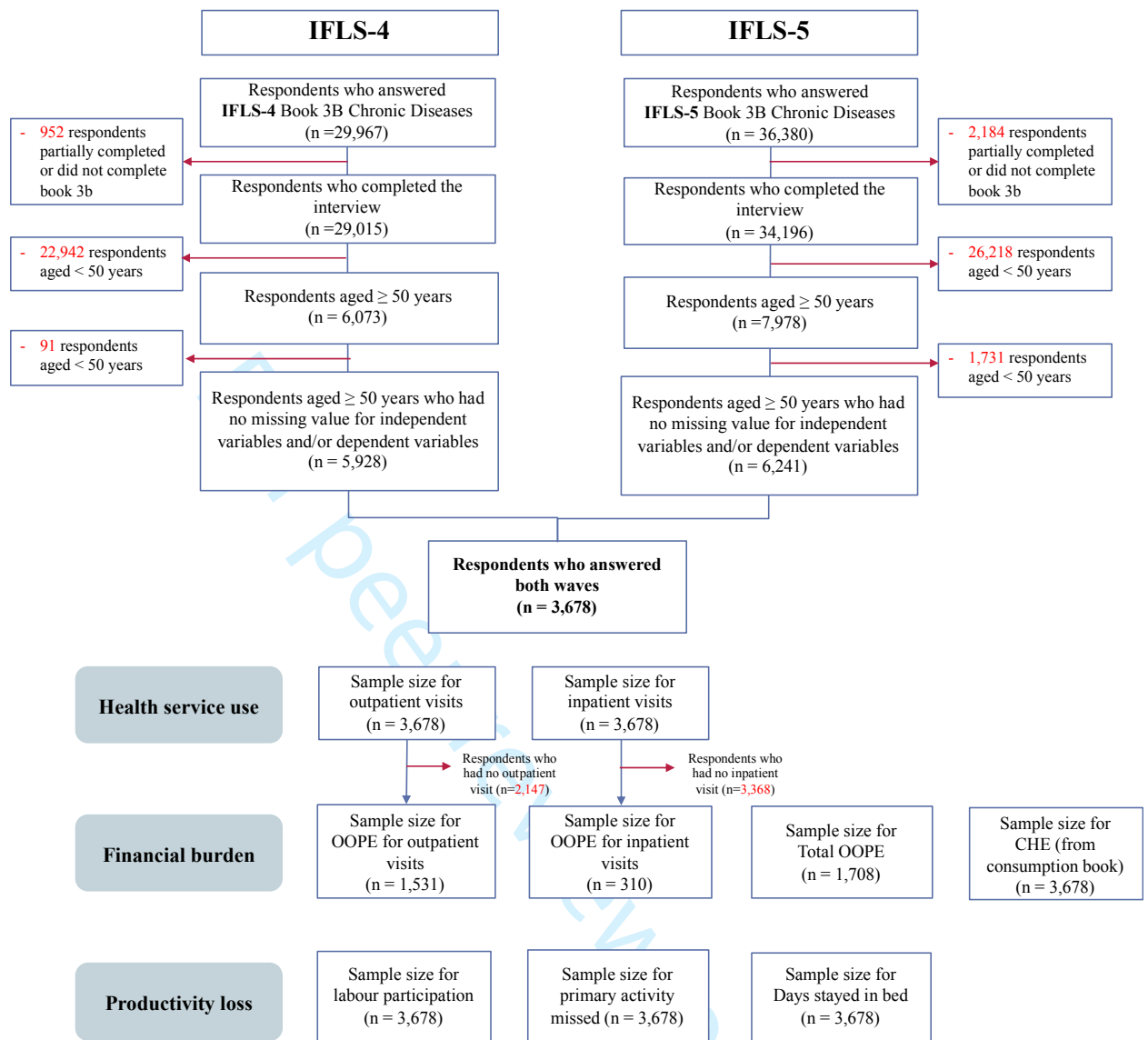
602

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



605
 606
 607 a) respondents who reported that they had 2 or more chronic conditions related to non-communicable
 608 diseases (NCDs). b) Pooled sample of Wave 4 and Wave 5. Q1-Q5 refer to household expenditure
 609 quintiles, where Q1 is the lowest and Q5 the highest household expenditure quintile.
 610

611 **Figure S1. Sample flowchart**



612

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				
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) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —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 <i>Cross-sectional study</i> —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) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —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

	Item	Recommendation	Reported on page	Relevant text from manuscript
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17	measurement	assessment methods if there is more than one group		measurements are available in Table S2
18 19 20 21 22 23 24 25 26 27 28 29 30 31	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.”
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51	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).
52 53 54 55 56 57 58 59 60	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) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —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

	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) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	32	Figure S1: Sampling flow chart
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	26	Table 1 and Table 2
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure		N/A
		<i>Cross-sectional study</i> —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				

	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”

614

615

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

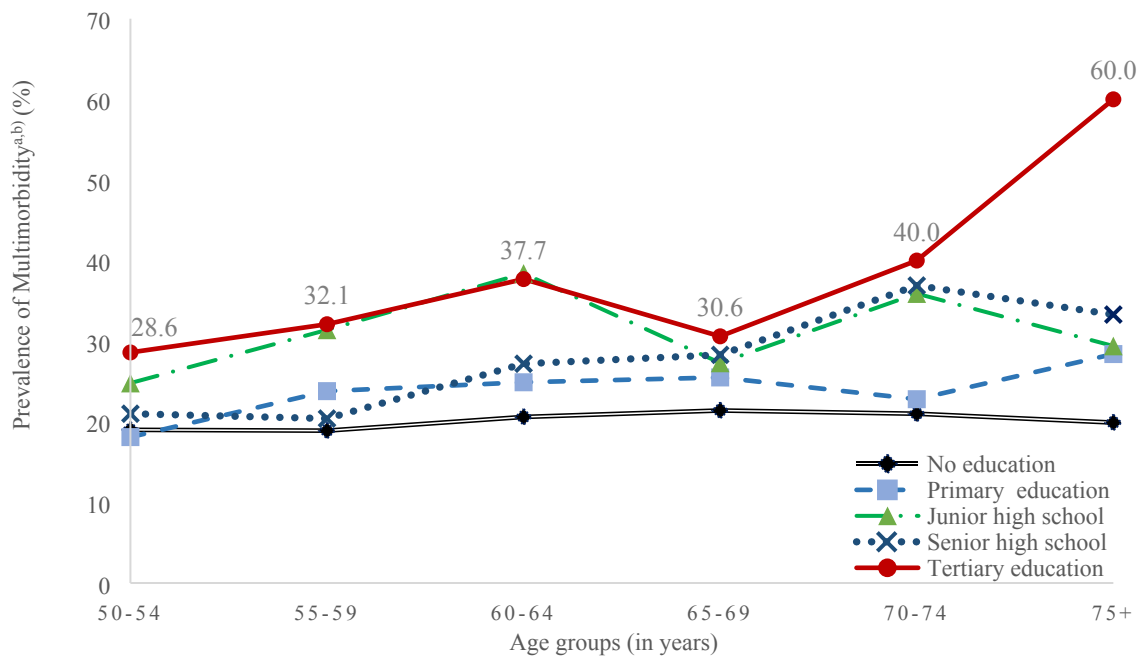
Variables	Type	Measurement	Source of measurement
Dependent variables:			
1) Health service use			
Outpatient care	Binary	0. No 1. Yes	RJ00: In the last 4 weeks have you visited a public hospital- <i>puskesmas</i> -private hospital-clinic-health worker or doctor's practice or been visited by a health 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- <i>puskesmas</i> -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	

Variables	Type	Measurement	Source of measurement
Multimorbidity	Binary	4. 2 NCDs	Book IIIB: CD06a – CD06r: Have a doctor/paramedic/nurse/ midwife ever told you that you had [list of chronic diseases]
		5. 3+ NCDs	
		0. No	
		1. Yes (had 2 or more chronic conditions related to NCDs)	
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	Book IIIA: Age: How old are you?
		1. 50-59 years	
		2. 60-69 years	
		3. 70-79 years	
Sex	Binary	4. 80+	Book IIIA: Sex: (identified by interviewers)
		0. Male	
		1. Female	
		0. Javanese	
Ethnicity	Categorical nominal	1. Sundanese	
		2. Others	
		0. Unmarried/Divorce	
Marital status	Binary	1. Married or living together	Book IIIA HR00b: Are you currently married?
		0. None	Book IIIA: DL06: What is the highest education level attended? DL07: What is the highest grade completed at school.
Education	Categorical ordinal	1. Elementary school	
		2. Junior high school	
		3. High school	
		4. Tertiary	
Occupation	Categorical nominal	0. None	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?
		1. Casual worker	
		2. Self-employed	
		3. Government/private worker	
Health insurance status	Binary	0. Uninsured (Not covered by any insurance)	Book IIIB: AK01: Are you the policy holder/primary beneficiary of health benefits-health insurance?
		1. Insured	
Per capita expenditure	Categorical ordinal	0. Q1 (lowest)	Book KS
		1. Q2	
		2. Q3	
		3. Q4	
		4. Q5 (highest)	
Residency	Binary	0. Rural	Book T-2: SC06: (identified by interviewers)
		1. Urban	
Region	Categorical nominal	0. Java-Bali	Book T-2: SC01: province (identified by interviewers)
		1. Sumatra	
		2. Nusa Tenggara	
		3. Kalimantan	
		4. Sulawesi	

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)

618

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

620

621

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.

622

623

624

625

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)

626

627

Note:

628

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

629

630

631 Table S5. Robustness check: descriptive summary and factors associated with
632 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)	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 (4.0, 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 (5.2, 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

633

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

Variables	Health service use			
	Outpatient		Inpatient	
	Any visit aOR (95% CI)	Number of visits IRR (95% CI)	Any visit aOR (95% CI)	Number of visits 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

637

638 **Table S7. Robustness check: The effect of multimorbidity on catastrophic health**
 639 **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

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

Variables	Productivity loss		
	Labour participation aOR (95% CI)	Days primary activity missed IRR (95% CI)	Days stayed in bed 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		0.55*** (0.49–0.63)	0.33*** (0.26–0.42)
Government/private	n/a	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 IFLS 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

643

645 **Table S9. Sensitivity analysis: the effect of multimorbidity on health service use**
 646 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

647

648 **Table S10. Sensitivity analysis: the effect of multimorbidity on catastrophic expenditure**
 649 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 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	1.12 (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

650
651
652**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

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

653

For peer review only

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 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) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —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 <i>Cross-sectional study</i> —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) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —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

	Item	Recommendation	Reported on page	Relevant text from manuscript
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17	measurement	assessment methods if there is more than one group		measurements are available in Table S2
18 19 20 21 22 23 24 25 26 27 28 29 30 31	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.”
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51	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).
52 53 54 55	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)”
56 57 58 59 60	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) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —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

	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) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	32	Figure S1: Sampling flow chart
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	26	Table 1 and Table 2
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure		N/A
		<i>Cross-sectional study</i> —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				

	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 caution 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”

BMJ Open

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

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-041870.R1
Article Type:	Original research
Date Submitted by the Author:	23-Dec-2020
Complete List of Authors:	<p>Marthias, Tiara; The University of Melbourne, Nossal Institute for Global Health; Gadjah Mada University, Department of Public Health, Faculty of Medicine, Public Health and Nursing</p> <p>Anindya, Kanya; The University of Melbourne, Nossal Institute for Global Health</p> <p>Ng, Nawi ; University of Gothenburg, Department of Public Health and Community Medicine</p> <p>McPake, Barbara; The University of Melbourne, Nossal Institute for Global Health</p> <p>Atun, Rifat; Harvard University T H Chan School of Public Health, Department of Global Health and Population</p> <p>Arfyanto, Hafiz ; SMERU Research Institute</p> <p>Hulse, Emily ; The University of Melbourne, Centre for Health Policy, School of Population and Global Health</p> <p>Zhao, Yang; The University of Melbourne, Nossal Institute for Global Health, The University of Melbourne; Peking University Health Science Centre, The George Institute for Global Health</p> <p>Jusril, Hafizah; Universitas Indonesia, Center for Health Research</p> <p>Pan, Tianxin; The University of Melbourne, Center for Health Policy, School of Population and Global Health</p> <p>Ishida, Marie; The University of Melbourne, Nossal Institute for Global Health</p> <p>Lee, John; The University of Melbourne, Nossal Institute for Global Health; Imperial College London, Department of Primary Care and Public Health, School of Public Health</p>
Primary Subject Heading:	Health policy
Secondary Subject Heading:	Public health, Health policy, Health economics
Keywords:	PUBLIC HEALTH, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health economics < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60





I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

4
5 Tiara Marthias^{†1,2}, Kanya Anindya^{†*1}, Nawi Ng³, Barbara McPake¹, Rifat Atun⁴, Hafiz
6 Arfyanto⁵, Emily S G Hulse⁶, Yang Zhao^{1,7}, Hafizah Jusril⁸, Tianxin Pan⁶, Marie
7 Ishida¹, John Tayu Lee^{1,9}

8
9 **Affiliations**

10 ¹Nossal Institute for Global Health, The University of Melbourne, Melbourne, Australia
11 ²Department of Public Health, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah
12 Mada, Yogyakarta, Indonesia ³Department of Public Health and Community Medicine, University
13 of Gothenburg, Sweden ⁴Department of Global Health and Population, Harvard T.H. Chan School
14 of Public Health, Harvard University, Boston, MA, USA ⁵SMeRU Research Institute, Jakarta,
15 Indonesia ⁶Center for Health Policy, School of Population and Global Health, The University of
16 Melbourne, Melbourne, Australia ⁷The George Institute for Global Health, Peking University Health
17 Science Center, Beijing, China ⁸Center for Health Research, Faculty of Public Health, Universitas
18 Indonesia, Depok, Indonesia ⁹Department of Primary Care and Public Health, School of Public
19 Health, Imperial College London, United Kingdom

20
21 [†] Co-first author (both contributed equally)

22 ^{*} Corresponding author

23 Postal address: The Nossal Institute for Global Health, level 5, 333 Exhibition Street,
24 Melbourne, Victoria 3010 Australia.

25 E-mail address: kanindya@student.unimelb.edu.au

26 Telephone number: +62 878 9966 9201

27 **Word count: 4004**

1
2
3 **29 Abstract**

4
5 **30 Objectives**

6
7
8 31 To examine noncommunicable diseases (NCDs) multimorbidity levels, and their
9
10 32 relation to households' socioeconomic characteristics, health service use, catastrophic
11
12 33 health expenditures, and productivity loss.
13
14
15 34

16
17 **35 Method**

18
19 36 We utilised a panel dataset from two waves of the Indonesian Family Life Survey
20
21 37 (IFLS) conducted in 2007 and 2014. IFLS is an ongoing longitudinal survey that is
22
23 38 representative of 83% of the total population in Indonesia. We included respondents
24
25 39 aged 50 years old and above in 2007 who participated in both waves. The total number
26
27 40 of participants in this study are 3,678 respondents. Our main outcomes are health
28
29 41 service use (outpatient and inpatient care), financial burden (catastrophic health
30
31 42 expenditure), and productivity loss (labour participation, days primary activity missed,
32
33 43 days stayed in bed). We applied multilevel logistic regression and negative binomial
34
35 44 regression models to assess the associations between NCD multimorbidity and the
36
37 45 binary outcome variables and count variables, respectively.
38
39
40
41
42
43
44
45
46
47

48
49 **47 Results**

50
51 48 Women were more likely to have NCD multimorbidity than men and the prevalence of
52
53 49 multimorbidity increased with higher socioeconomic status. NCD multimorbidity was
54
55 50 associated with a substantially higher number of outpatient visits (compared with those
56
57 51 without NCDs, incidence rate ratio [IRR] 4.30, 95% CI 3.37–5.47 for individuals with
58
59 52 three or more NCDs), a higher number of hospital visits (IRR 5.76, 95% CI 3.11–10.66
60
53 for individuals with three or more NCDs). NCD multimorbidity was also associated

1
2
3 54 with a greater likelihood of experiencing catastrophic health expenditure (for three or
4
5 55 more NCDs, adjusted odds ratio [aOR] 1.69, 95% CI 1.02–2.81) and lower participation
6
7 56 in the labour force (aOR 0.18, 95% CI 0.10–0.34) compared to those without NCDs.
8
9

10 57

11 58 **Conclusions**

12
13
14 59 NCD multimorbidity is associated with substantial direct and indirect costs to
15
16
17 60 individuals, households, and the wider society. Our study highlights the importance of
18
19 61 preparing health systems for addressing the burden of multimorbidity in LMICs.
20
21

22 62

23
24 63 **Keywords** Multimorbidity, Indonesia, noncommunicable diseases, health service use,
25
26 64 catastrophic health expenditure, productivity loss.
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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.

65

66 Introduction

67 Noncommunicable diseases (NCDs) continues to be the leading cause of global burden
68 of diseases, with 78% of NCD-related mortality concentrated in low-income and
69 middle-income countries (LMICs).¹ The current COVID-19 pandemic highlights that
70 the presence of NCDs can increase the fatality risk of a communicable disease.² In
71 Indonesia, the third most populous country among LMICs (after China and India) with
72 a population of 273 million, has seen rapid demographic and epidemiological
73 transitions over the last few decades. The threat of NCDs is expected to rise with the
74 aging population (population aged 65 or above), which is projected to account for a
75 quarter of the population by 2070.³ Concurrently, the prevalence of NCD
76 multimorbidity, defined as the presence of two or more NCDs, is expected to rise
77 rapidly in many LMICs, as both life expectancy and exposure to risk factors increase.⁴
78 Indonesia has started recognising the burden of NCDs due to its substantial contribution
79 to the top causes of death and disability-adjusted life years (DALYs).⁵ However, current
80 Indonesia health programs remain limited to curative services, focusing on single

1
2
3 81 chronic disease as opposed to assessing and mitigating the impact of multimorbidity on
4
5 82 the individual, health system and wider society.
6
7
8 83

9
10 84 COVID-19 pandemic emphasises the importance of health systems responsiveness to
11
12 85 multimorbidity. Historically, the growing burden of multimorbidity in LMICs were
13
14 86 highlighted in the United Nations High-Level Meetings on NCDs in 2011, 2014, and
15
16
17 87 2018.⁶ LMICs typically have low levels of government expenditure for health and
18
19 88 inadequate health insurance coverage, which often results in higher levels of out-of-
20
21 89 pocket expenditure (OOPE) and risk of impoverishing patients with chronic health
22
23 90 conditions.^{7,8} The economic burden of multimorbidity is further compounded by the
24
25
26 91 fact that multiple healthcare specialists typically manage multimorbid patients in
27
28 92 LMICs.⁹ This leads to inefficiencies with numerous different hospital visits,
29
30 93 polypharmacy, and suboptimal disease management.^{9,10}
31
32
33 94

34
35 95 While the Indonesian health system is mainly funded by the government, it only spends
36
37 96 around 2% of its GDP on health, which is significantly lower than other LMICs with
38
39 97 comparable income level.¹¹ Approximately half of all health spending is covered by the
40
41 98 public sector and one-third comes from OOP payment.¹² While the primary health care
42
43 99 (PHC) centres are designed as gatekeepers for primary prevention for NCDs, studies
44
45 100 have found limited capacity of PHC in proper management of NCDs.^{13–15} There is also
46
47 101 high public funding allocations to curative services at the hospital-level,¹⁶ with limited
48
49 102 investment in preventive and promotive health services.¹² Further, the poor and those
50
51 103 living in limited-resource regions have generally lower hospital utilisation due to
52
53
54 104 geographical barriers and high transportation costs.^{17,18} Low overall government health
55
56
57
58
59
60

1
2
3 105 spending, coupled with limited investment in PHC and the high burden of NCDs may
4
5 106 further increase the high OOPE in Indonesia and inequitable access to care.⁵
6
7
8 107

9
10 108 The Indonesian national health insurance program expansion in 2014 was designed to
11
12 109 achieve universal coverage by 2019.¹⁹ However, as of August 2020, the insurance
13
14 110 coverage was only at 85.5%,²⁰ leaving around 40 million people remain uncovered.
15
16
17 111 Furthermore, the program has been in funding deficit since its inception and recent
18
19 112 studies identified that the insurance program may not be financially sustainable.^{1,2}
20
21 113 Further, NCDs were responsible for around 60% of total spending of the insurance
22
23 114 program. Therefore, addressing NCDs through preventive and promotive programs is
24
25 115 pertinent to strengthen the Indonesian health system and the sustainability of its health
26
27 116 insurance program.
28
29

30 117
31
32
33 118 Evidence from high-income countries (HICs) has found that apart from the negative
34
35 119 impact on health outcomes, multimorbidity imposes substantial economic costs on
36
37 120 individuals and households. This is because patients with multimorbidity incur large
38
39 121 medical expenditures and are more likely to be absent from work.^{8,21,22} However, there
40
41 122 is no previous study in Indonesia that has examined the economic burden of NCD
42
43 123 multimorbidity, as earlier studies have focused on the burden of a single NCD.²³ Results
44
45 124 from this study may inform health systems reform across the region and be applicable
46
47 125 to similar LMICs. We present the first study that uses longitudinal data to examine
48
49 126 NCD multimorbidity levels, and their relationship to households' socioeconomic
50
51 127 characteristics, health service use, catastrophic health expenditures, and productivity
52
53 128 loss.
54
55
56
57

58 129
59
60

1
2
3 130 **Methods**

4
5 131 **Sample and data**

6
7
8 132 We utilised panel data from two waves of the Indonesian Family Life Survey (IFLS)
9
10 133 conducted in 2007 (Wave 4) and 2014 (Wave 5). IFLS is an ongoing longitudinal
11
12 134 survey that started in 1993 with four subsequent rounds of data collection (1997/1998,
13
14 135 2000, 2007/2008, and 2014). The original sample was based on 13 out of 27 provinces
15
16 136 in 1993, representing 83% of the population. Wave 5 was conducted between
17
18 137 September 2014–March 2015, with 76% re-contact rate from the main respondents of
19
20 138 Wave 1. The dataset contains information at the individual- and household-level ,
21
22 139 including sociodemographic characteristics, healthcare utilisation and expenditure, and
23
24 140 labour participation. The objectives and methods of the IFLS are detailed
25
26 141 elsewhere.^{24,25} This study included respondents aged 50 years and above in 2007 who
27
28 142 participated in both Waves 4 and 5, and excluded those with missing values for the
29
30 143 study variable. Our final sample is 3,678 respondents and a sample flowchart is
31
32 144 presented in Figure S1.
33
34
35
36
37

38 145 **Variables**

39
40
41 146 **Multimorbidity**

42
43 147 Our main variable of interest was multimorbidity. Fourteen types of NCDs were
44
45 148 included in Wave 5, but only 10 NCDs in Wave 4. For consistency, our main analysis
46
47 149 used 10 NCDs that were available in both waves, as the following: hypertension,
48
49 150 diabetes, asthma, heart attack/coronary heart diseases, liver disease, stroke, cancer,
50
51 151 arthritis/rheumatism, hypercholesterolemia, and depression/mental illness. The four
52
53 152 NCDs that were only included in Wave 5 were: prostate diseases, kidney diseases
54
55 153 (excluding malignancy), digestive diseases, and memory-related diseases.
56
57
58
59
60

1
2
3 155 NCD status was either identified through self-reporting or physical examination. In the
4
5 156 self-report section, respondents who answered affirmatively to the question, “Has a
6
7 157 doctor/paramedic/nurse/midwife ever told you that you had any of these conditions?”,
8
9 158 were defined as reporting an NCD. For hypertension and hypercholesterolemia, the
10
11 159 diagnoses were confirmed through a physical examination conducted by trained nurses,
12
13 160 i.e. blood pressure and total cholesterol levels. All IFLS respondents aged 15 years and
14
15 161 older had their blood pressure recorded three times on alternate arms using Omron self-
16
17 162 inflating sphygmomanometers by trained nurses.^{24,25} In our analysis, a respondent was
18
19 163 categorised as having hypertension if the mean measurement of systolic blood pressure
20
21 164 was 140 mm Hg and/or mean diastolic blood pressure was 90 mm Hg or the respondent
22
23 165 self-reported having been diagnosed with hypertension.²⁶ We also included
24
25 166 hypercholesterolemia, defined as total blood cholesterol value 240 mg/dl, as
26
27 167 morbidity.²⁷ It is important to note that different measurements of hypercholesterolemia
28
29 168 were used in Wave 4 and 5. Blood test for total cholesterol was performed in Wave 4
30
31 169 as opposed to self-reporting of hypercholesterolemia in Wave 5.
32
33
34
35
36
37
38
39
40

41 171 A total of 10 NCDs were used to quantify the number of NCDs (0, 1, 2, 3 or more) and
42
43 172 respondents with two or more NCDs were categorised as having multimorbidity (0 or
44
45 173 1). Previous studies have typically considered hypertension, obesity, and
46
47 174 hypercholesterolemia as risk factors of NCDs and their inclusion in the multimorbidity
48
49 175 clustering remains inconsistent.^{23,28} Therefore, in the sensitivity analysis, we included
50
51 176 obesity, defined as having BMI ≥ 25 kg/m², in the clustering of multimorbidity.²⁹ All
52
53 177 statistical analyses were conducted using STATA 13.0.
54
55
56
57
58
59
60

1
2
3 180 ***Outcome variables***
4

5 181 The three main outcomes are: health service use and financial burden as the direct cost
6
7 182 and productivity loss as the indirect cost of multimorbidity. Respondents were asked
8
9 183 about the number of outpatient visits (in the last four weeks) and inpatient visits (in the
10
11 184 last 12 months) and OOPE. The data on OOPE was also collected with four weeks and
12
13 185 12 months recall period for outpatient and inpatient visits, respectively. We calculated
14
15 186 the total annual OOPE by multiplying OOPE for outpatient visits with 13 (as the
16
17 187 reference period of outpatient expenditure in the IFLS is four weeks and a year consists
18
19 188 of 52 weeks), and added OOPE for inpatient visits. The total OOPE reflects all costs
20
21 189 associated with outpatient or inpatient visits, including medication, medical
22
23 190 consultation, and laboratory tests.
24
25
26
27
28
29

30 191
31 192 Catastrophic health expenditure occurs when OOPE exceed certain thresholds of a
32
33 193 household's expenditure. The thresholds used in this study were 10% and 25% of total
34
35 194 household expenditure (as proposed by the Sustainable Development Goal 3 targets),
36
37 195 and the WHO's recommendation at 40% of household's capacity to pay. Capacity to
38
39 196 pay is defined as the household's ability to pay for other expenses, including medical
40
41 197 costs, after having household subsistence needs met.³⁰ Household subsistence needs are
42
43 198 proxied by the household non-food expenditure variable. Catastrophic health
44
45 199 expenditure () occurrence is expressed as follows:
46
47
48

49 200
$$cata_h = 1 \text{ if } \frac{HS_h}{THE_h} \text{ or } \frac{HS_h}{CTP_h} > z, \text{ and otherwise is zero.}$$

50
51
52 201 Where HS_h is the total OOPE for health, THE_h is the total household expenditure, CTP_h
53
54 202 is capacity to pay, and z is the threshold of capacity to pay. In using the proportion of
55
56 203 total OOPE for health to total household expenditure (THE), the threshold z was set at
57
58 204 10% and 25%. Further, in using the proportion of OOPE for health to capacity to pay
59
60

1
2
3 205 (CTP), the threshold z was set at 40%. All monetary values were adjusted for inflation
4
5 206 and converted to 2014 International Dollars.³¹
6
7
8 207

9
10 208 Productivity loss was assessed based on: (1) labour participation; (2) the number of
11
12 209 days of primary activity missed due to poor health; and (3) number of days confined to
13
14 210 bed. Labour participation status was defined as the respondent's employment status at
15
16 211 the time of the survey. The number of days of primary daily activity missed and days
17
18 212 confined to bed were included in the health conditions section of the survey, with a four
19
20 213 week recall period.
21
22
23
24 214

25 26 215 ***Covariates***

27
28 216 Sociodemographic factors included were: sex, age groups (50-60, 61-70, above 70
29
30 217 years), marital status (currently and not currently married), education (no education,
31
32 218 primary, junior high school, senior high school, tertiary), ethnicity (Javanese,
33
34 219 Sundanese, others), coverage of health insurance (no, yes), type of work (unemployed,
35
36 220 casual, self-employed, government/private), and respondents' economic status (per
37
38 221 capita expenditure for consumption). The economic status was categorised into
39
40 222 quintiles: q1 (lowest) to q5 (highest). We also included residency (rural, urban), region
41
42 223 of residency (Java-Bali, Sumatra, Nusa Tenggara, Kalimantan, Sulawesi), and period
43
44 224 (using wave 2007 as the reference group) as covariates. Detailed definitions and
45
46 225 categorisations are available in Table S1. It should be noted that IFLS did not include
47
48 226 the eastern regions, Papua and West Papua, which are considered to be underdeveloped.
49
50
51
52
53
54 227

228 **Statistical analysis**

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

246 **Patient and public involvement**

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

248

249 **Results**

250 **Descriptive statistics**

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

1
2
3 253 female, 74.4% were married, 16.5% had at least secondary education level or above
4
5 254 and only 25.5% had health insurance coverage. In 2014, the median age was 65 years
6
7 255 (IQR 60–72), and health insurance coverage increased to 42.8%.
8
9

10 256

11
12 257 A similar prevalence of NCD multimorbidity was observed between 2007 (21.0%, 95%
13
14 258 CI 19.6–22.6) and 2014 (22.0%, 95% CI 20.6–23.6). The prevalence of multimorbidity
15
16 259 increased with rising socioeconomic status. For example, in 2014, the prevalence
17
18 260 increased from 18.0% (95% CI 16.9–20.7) to 41.2% (95% CI 31.6–51.6) between
19
20 261 respondents with no education and those with tertiary education. Similarly, the
21
22 262 prevalence increased from 13.5% (95% CI 11.1–16.2) to 36.2% (95% CI 32.2–40.5)
23
24 263 between the lowest and highest wealth quintiles. The trend of increasing multimorbidity
25
26 264 was observed for all age groups, shown in Figure 1, where the fifth and fourth wealth
27
28 265 quintiles had a higher prevalence of NCD multimorbidity than the lower quintiles. The
29
30 266 prevalence of multimorbidity by level of education is available in Figure S2.
31
32

33 267

34
35
36
37 268 The regression results show that NCD multimorbidity was more likely among those
38
39 269 with higher socioeconomic status (Table 1). Respondents in the highest wealth quintile
40
41 270 were more likely to report NCD multimorbidity, compared with those in the lowest
42
43 271 quintile (aOR 2.22, 95% CI 1.72–2.86). Compared with those with lower educational
44
45 272 attainment, respondents with higher educational attainment were more likely to
46
47 273 experience NCD multimorbidity (aOR 1.54, 95% CI 1.01–2.34 for tertiary level
48
49 274 completed). Additionally, the prevalence of multimorbidity was higher in females than
50
51 275 males (aOR 1.74, 95% CI 1.46–2.08) and those living in urban areas (aOR 1.41, 95%
52
53 276 CI 1.19–1.67). The ICC shows that above 53% ($1 - [0.34 + 0.13]$) of the variance can be
54
55 277 ascribed to between-individual level differences (Table S3).
56
57
58
59
60

278 **Multimorbidity and health service use**

279 The probability of using outpatient and inpatient care and the number of visits increased
280 with more NCD diagnoses (Table 2, Table 3). Respondents with a single NCD were
281 1.35 times more likely (95% CI 1.15–1.58) to have experienced an outpatient visit in
282 the past four weeks compared to those without an NCD. The odds of an outpatient visit
283 increased to 4.66 times (95% CI 3.55–6.11), while the incidence rate increased by 4.25
284 times (95% CI 3.33–5.42) in those with three or more NCDs. Furthermore, the
285 incidence of inpatient visits was 3.68 times (95% CI 2.21–6.12) higher in those with
286 three or more NCDs, compared to those without an NCD.

287
288 We reported the results of ICC in Table S3. We found that 14% and 11% of the variance
289 in the outpatient visit were attributable to the differences within-individuals and
290 households, respectively. Between-individual variation accounted for the largest
291 variation, where it explained 75% (1-[0.14+0.11]) and 65% (1-[0.25+0.12]) of
292 outpatient and inpatient visit, respectively. No influence of district-level variables was
293 found (ICC=0).

295 **Multimorbidity and financial burden**

296 The mean OOPE for outpatient care incurred by respondents during the last four weeks
297 increased from INT\$17 in those without any NCDs to INT\$60 in those with three or
298 more NCDs in 2014 (Table 2). Similarly, for inpatient visits, having three or more
299 NCDs resulted in a higher mean OOPE of \$762 (SD ±\$1,421) compared to \$566 (SD
300 ±\$1,880) for those without any NCDs. The total annual OOPE also increased from \$295
301 (SD ±\$977), among those without any NCDs, to \$968 (SD ±\$4,313) among those with
302 three or more NCDs. Table 2 also presents the proportion of respondents with

1
2
3 303 catastrophic health expenditure using different thresholds. The results using 10% and
4
5 304 25% of THE, and 40% of non-food consumption thresholds found that households with
6
7
8 305 more than two NCDs had a higher proportion of catastrophic health expenditure
9
10 306 compared to households without any member having any NCDs.

11
12 307

13
14 308 Table 4 presents the logistic regression results for the proportion of respondents who
15
16 309 experienced catastrophic health expenditure using different thresholds. At 10% of THE
17
18 310 as the threshold, having two NCDs increases the odds of catastrophic health
19
20 311 expenditure to 1.58 times (95% CI 1.06–2.35), compared to having no NCDs. These
21
22 312 odds increased to 1.69 times for those having three NCDs or more (95% CI 1.02–2.81).
23
24 313 At the 25% and 40% thresholds, we found no significant association between the
25
26 314 number of NCD and the incidence of catastrophic health expenditure.
27
28
29
30

31 315

32 316 **Multimorbidity and productivity loss**

33
34 317 More NCDs diagnoses were associated with greater productivity loss (Table 2, Table
35
36 318 5). For example, among those aged 50–60 years old, only 49.8% (95% CI 36.7–62.9)
37
38 319 of respondents with three or more NCDs were employed, compared with 84.3% (95%
39
40 320 CI 79.8–88.0) of respondents without NCDs (Table 2). The mean number of days of
41
42 321 primary daily activity missed increased from 2.7 days (SD \pm 6.0), for those without any
43
44 322 NCDs, to 10.1 days (SD \pm 12.1) for those with three or more NCDs. The mean number
45
46 323 of days confined to bed also increased among those with three or more NCDs.
47
48
49
50

51 324

52
53
54 325 Individuals diagnosed with three or more NCDs were 0.23 times less likely (95% CI
55
56 326 0.16–0.33) to be employed compared to those without NCDs (Table 5). Compared with
57
58 327 those without NCD, being diagnosed with three or more NCDs were expected to have
59
60

1
2
3 328 a higher incidence rate of missing days of primary activity (IRR 2.59, 95% CI 1.97–
4
5 329 3.41) as well as days spent in bed (IRR 2.64, 95% CI 1.60–4.36). We found that 48%
6
7
8 330 of the variance in labour participation was due to within-individual variations, while
9
10 331 between-individual variation accounted for 23% ($1 - [0.48 + 0.28 + 0.01]$) (Table S3).

11
12
13 332

14 15 333 **Robustness check**

16
17 334 Our robustness analysis using 2014 cross-sectional dataset that consists of 14 physical
18
19
20 335 NCDs (Table S4–7) showed consistent results with our original findings. Higher
21
22 336 household expenditure and higher education were associated with greater burden of
23
24 337 multimorbidity. Multimorbidity was also associated with higher health care use, higher
25
26 338 incidence of catastrophic health expenditures, and lower productivity. The association
27
28 339 between multimorbidity and catastrophic health expenditure was more pronounced in
29
30 340 the cross-sectional analysis. Our inclusion of obesity in the clustering of multimorbidity
31
32 341 also yields consistent results (Table S8–10).

33
34
35
36
37 342

38 39 40 343 **Discussion**

41
42 344 Our study provides the first comprehensive analysis of multimorbidity in Indonesia
43
44 345 using the only large panel dataset in Indonesia. Our study reveals that almost one in
45
46 346 four of our study population has at least two NCDs, with 6.5% having three or more in
47
48 347 2014. Our findings show a higher prevalence of multimorbidity in wealthier population
49
50 348 groups. Multimorbidity was associated with a higher use of healthcare services, higher
51
52 349 probability of catastrophic health expenditure, and a reduction in productivity.

53
54
55
56
57 350
58
59
60

1
2
3 351 Analyses of socioeconomic gradients of NCDs in HICs routinely find negative
4
5 352 socioeconomic gradients. However, this is not the case for LMICs, which have a more
6
7
8 353 mixed pattern of the distribution of risk factors.^{34,35} Other studies find a similar pattern
9
10 354 with diabetes and cardiovascular diseases in LMICs undergoing epidemiological
11
12 355 transition.³⁵ These conditions predominate in high-income quintiles in early stages of
13
14 356 transition, which may explain our findings on the higher prevalence of NCD
15
16 357 multimorbidity among more affluent population. We also found that obesity was more
17
18 358 prevalent in wealthier quintiles. As obesity is associated with several NCDs
19
20 359 (cardiovascular diseases, hypertension, stroke, cancer, arthritis and
21
22 360 hypercholesterolemia),³⁶ this may explain our findings on socioeconomic gradients of
23
24
25 361 NCDs. Further, our results on socioeconomic patterning of multimorbidity can be
26
27 362 explained by the fact that higher-income and higher-educational groups have better
28
29 363 health literacy and access to healthcare services. And thus, are more likely to have
30
31 364 NCDs diagnosed than lower socio-income groups.
32
33
34
35
36
37

366 Our findings showing the association between having more NCDs and greater use of
367 health services are in line with earlier studies from both HICs and LMICs.^{9,28,37} The
368 presence of NCD multimorbidity was also associated with a greater financial burden,
369 which is mainly driven by higher healthcare use. These findings are consistent with
370 earlier studies.^{10,28,37,38} Based on a previous Indonesian study, four NCDs
371 (hypertension, diabetes, heart problems, and stroke) are the leading causes of mortality
372 and were estimated to account for 12% of Indonesia's OOPE in 2020.²² Furthermore,
373 the impoverishment effect of multimorbidity has been previously documented and is
374 confirmed in our study.^{7,21,22,37}

375
58
59
60

1
2
3 376 This study contributes to the growing evidence that multimorbidity has a substantial
4
5 377 impact on disability and productivity.^{7,9,22} Interventions that can help effectively
6
7 378 prevent and manage multimorbidity have the potential for generating substantial returns
8
9
10 379 on improved health, work productivity and social benefits. However, a large portion of
11
12 380 the Indonesia government health expenditure is still geared towards curative care.⁵
13
14 381 Renewing the focus on health promotion and NCD prevention requires a strong PHC
15
16 382 system.⁹ PHC is the entry point of a sustainable health system for the early detection of
17
18 383 risk factors and initiation of a treatment-seeking pathway for patients with NCDs, and
19
20 384 thus, plays a crucial role for NCD prevention and provision of long-term integrated
21
22 385 care. Such policies would be in line with the current program of the Ministry of Health
23
24 386 in Indonesia to reorient public PHC to provide more promotive and preventive health
25
26 387 services, such as through the implementation of Chronic Diseases Management
27
28 388 Program (Prolanis) in PHC.^{12,39} However, the participation in this program remains low
29
30 389 due to the poor access to PHC facilities, especially in non-Java-Bali regions. Engaging
31
32 390 the private sector, which makes up 60% of health facilities in Indonesia, is warranted
33
34 391 to expand the coverage of NCD promotive and prevention activities.⁴⁰ Furthermore, the
35
36 392 development of digital health solution and telehealth for NCDs prevention and control
37
38 393 should be included in the national plan.⁴¹
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

1
2
3 401 multidisciplinary teams lead by general practitioners.⁴² There is also a need to
4
5 402 strengthen the coordination of patient management between the primary and secondary
6
7 403 care. Similar to many LMICs and neighbouring countries in Asia, healthcare delivery
8
9 404 in Indonesia remains fragmented and hospital-centred, with little coordination among
10
11 405 healthcare providers across different tiers of the system.⁴⁵
12
13
14
15 406

16
17 407 Furthermore, under the current national health insurance scheme, the hospital
18
19 408 reimbursement system that uses case-based groups has created significant gaps between
20
21 409 reimbursable costs and actual hospital expenses.⁴⁶ The reimbursement system, which
22
23 410 is mainly based on primary diagnosis, limits the hospital's capacity and willingness to
24
25 411 treat complicated cases such as those with multimorbidity.⁴⁷ Thus, it is important to
26
27 412 develop a clinical guideline for multimorbidity in Indonesia and other LMICs, along
28
29 413 with payment systems that would ensure quality health services at both primary and
30
31 414 secondary levels of care for patients with multimorbidity.^{9,40} It is also worth noting that
32
33 415 Indonesia is still facing the double burden of infectious and chronic diseases. Therefore,
34
35 416 multimorbidity care delivery model needs to pay attention to the management of NCDs
36
37 417 alongside infectious diseases.
38
39
40
41
42
43
44

45 419 There are several limitations to our study. First, the IFLS-5 was conducted between
46
47 420 2014 and 2015, which may not be able to capture the current prevalence of
48
49 421 multimorbidity in Indonesia. Despite this limitation, IFLS is the only longitudinal
50
51 422 survey available in Indonesia that is useful to produce more accurate estimates
52
53 423 compared with using a cross-sectional dataset (e.g. the National Socioeconomic
54
55 424 Survey). Second, our findings should be interpreted with caution since the assessment
56
57 425 of NCDs was mostly based on self-reporting. This may cause misreporting of the true
58
59
60

1
2
3 426 diagnoses and prevalence of multimorbidity. The health service use and OOPE were
4
5 427 also based on self-reporting and may be prone to recall bias.⁴⁸ The use of self-reported
6
7 428 diagnoses limits our assessment of the actual severity of the diseases, which may vary
8
9 429 across socioeconomic status. Future studies should consider using different datasets
10
11 430 (such as clinical dataset from the hospital) and applying clinical metrics such as
12
13 431 Charlson index, which could more objectively capture disease severity and predict the
14
15 432 health outcomes.⁴⁹ Third, the IFLS sample did not include Indonesia eastern regions.
16
17 433 There is a need to extend the multimorbidity assessment to the remaining regions.
18
19 434 Finally, this research intentionally focused on the older population due to a significantly
20
21 435 higher burden of NCDs in this population group. Future research should use cohort data
22
23 436 to follow patients over a more extended time period to examine the impact of
24
25 437 multimorbidity and its effects in younger population groups in LMICs.²²
26
27
28
29
30
31
32

33 **Conclusion**

34
35 440 Multimorbidity poses substantial costs to individuals, households, health system, and
36
37 441 the wider society in Indonesia, which has an increasingly aging population.
38
39 442 Policymakers and employers in Indonesia should carefully design and invest in targeted
40
41 443 public health and workplace interventions at the individual and population level to avert
42
43 444 the adverse health and economic consequences of NCD multimorbidity.
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 446 **Declarations**

4
5 447 **Abbreviation**

6
7 448 CHE: Catastrophic health expenditure; HICs: High-income countries; IFLS: Indonesian Family Life
8
9 449 Survey; LMICs: Low-middle income countries; NCDs: Noncommunicable diseases; OOPE: Out-
10
11 450 of-pocket expenditure; PHC: Primary health care.

12
13 451 **Competing interests**

14
15 452 The authors have declared that no competing interests exist.

16
17 453 **Ethics approval**

18
19 454 The IFLS has been approved by ethics review boards at RAND Corporation and Gadjah Mada
20
21 455 University in Indonesia. Written informed consent was sought from all respondents prior to data
22
23 456 collection. As this study used IFLS publicly available datasets that contain no personal identification
24
25 457 of the respondents, no further ethical approval was sought.

26
27 458 **Author's contributions**

28
29 459 Author's contributions: The aim of the research was developed by TM, KA, JL. The methodology
30
31 460 development and analysis were conducted by TM, KA, HA, TP, JL. EH assisted in drafting the
32
33 461 discussion section and proofread all section. YZ, HJ, MI contributed to background and discussion
34
35 462 section. NN, BM, RA, JL provided critical input in revising the manuscript. All authors reviewed,
36
37 463 edited and commented on multiple versions of the manuscript.

38
39 464 **Availability of data and materials**

40
41 465 The datasets are publicly accessible after registration ([https://www.rand.org/well-being/social-and-](https://www.rand.org/well-being/social-and-behavioral-policy/data/FLS/IFLS/access.html)
42
43 466 [behavioral-policy/data/FLS/IFLS/access.html](https://www.rand.org/well-being/social-and-behavioral-policy/data/FLS/IFLS/access.html)).

44
45 467 **Acknowledgements**

46
47 468 The authors of the paper express sincere gratitude to the RAND for providing access to the data.
48
49 469 We acknowledge Nur Arna Sucianti from SurveyMeter, for guiding us with data merging.

50
51 470 **Funding**

52
53 471 This research received no specific grant from any funding agency in the public, commercial or not-
54
55 472 for-profit sectors.

473 **References**

- 474 1 World Health Organization. Noncommunicable diseases country profiles 2018.
475 World Health Organization, 2018 <https://apps.who.int/iris/handle/10665/274512>.
476 (accessed Oct 10, 2019).
- 477 2 Zhang L, Sun W, Wang Y, *et al*. Clinical Course and Mortality of Stroke Patients
478 With Coronavirus Disease 2019 in Wuhan, China. *Stroke* 2020; **51**: 2674–82.
- 479 3 United Nations, Department of Economic and Social Affairs, Population Division.
480 World Population Prospects 2019, Online Edition. Rev. 1. 2019. UN DESA, 2019
481 <https://population.un.org/wpp/Download/Standard/Population/> (accessed March 8,
482 2020).
- 483 4 Hussain MA, Huxley RR, Al Mamun A. Multimorbidity prevalence and pattern in
484 Indonesian adults: an exploratory study using national survey data. *BMJ open* 2015;
485 **5**: e009810.
- 486 5 Mboi N, Surbakti IM, Trihandini I, *et al*. On the road to universal health care in
487 Indonesia, 1990–2016: a systematic analysis for the Global Burden of Disease Study
488 2016. *The Lancet* 2018; **392**: 581–591.
- 489 6 United Nations. Political declaration of the third high-level meeting of the General
490 Assembly on the prevention and control of non-communicable diseases. United
491 Nations, 2018 https://www.un.org/en/ga/search/view_doc.asp?symbol=A/RES/73/2
492 (accessed March 8, 2020).
- 493 7 Sum G, Hone T, Atun R, *et al*. Multimorbidity and out-of-pocket expenditure on
494 medicines: a systematic review. *BMJ global health* 2018; **3**: e000505.
- 495 8 Wang L, Si L, Cocker F, Palmer AJ, Sanderson K. A systematic review of cost-of-
496 illness studies of multimorbidity. *Applied health economics and health policy* 2018;
497 **16**: 15–29.
- 498 9 Barnett K, Mercer SW, Norbury M, Watt G, Wyke S, Guthrie B. Epidemiology of
499 multimorbidity and implications for health care, research, and medical education: a
500 cross-sectional study. *The Lancet* 2012; **380**: 37–43.
- 501 10 Salisbury C. Multimorbidity: redesigning health care for people who use it. *The*
502 *Lancet* 2012; **380**: 7–9.
- 503 11 World Bank Group. Indonesia Health Financing System Assessment : Spend More,
504 Right and Better. Washington, DC: World Bank, 2016
505 <https://openknowledge.worldbank.org/handle/10986/25363> (accessed Sept 24,
506 2020).
- 507 12 Gani A, Budiharsana M. The consolidated report on Indonesia health sector review
508 2018. Jakarta, Indonesia: Bappenas, 2018.
- 509 13 Werdhani RA. Medical problem in Asia pacific and ways to solve it: The roles of
510 primary care/family physician (Indonesia Xperience). *J Family Med Prim Care*
511 2019; **8**: 1523–7.

- 1
2
3 512 14Rokx C. New insights into the provision of health services in Indonesia: A health
4 513 workforce study. World Bank Publications, 2010
5 514 <http://documents1.worldbank.org/curated/en/799111468038325818/pdf/538830PUB>
6 515 [0Heal101Official0Use0Only1.pdf](http://documents1.worldbank.org/curated/en/799111468038325818/pdf/538830PUB0Heal101Official0Use0Only1.pdf).
7
8
9 516 15Rajan VS, Patil A, Pambudi ES, Junedi B. Is Indonesia Ready to Serve? : An
10 517 analysis of Indonesia's primary health care supply-side readiness. Washington,
11 518 D.C. : World Bank Group: World Bank, 2018
12 519 [http://documents.worldbank.org/curated/en/484351538653658243/Is-Indonesia-](http://documents.worldbank.org/curated/en/484351538653658243/Is-Indonesia-Ready-to-Serve-An-Analysis-of-Indonesia-s-Primary-Health-Care-Supply-Side-Readiness)
13 520 [Ready-to-Serve-An-Analysis-of-Indonesia-s-Primary-Health-Care-Supply-Side-](http://documents.worldbank.org/curated/en/484351538653658243/Is-Indonesia-Ready-to-Serve-An-Analysis-of-Indonesia-s-Primary-Health-Care-Supply-Side-Readiness)
14 521 [Readiness](http://documents.worldbank.org/curated/en/484351538653658243/Is-Indonesia-Ready-to-Serve-An-Analysis-of-Indonesia-s-Primary-Health-Care-Supply-Side-Readiness) (accessed March 20, 2019).
15
16 522 16Mahendradhata Y, Trisnantoro L, Dewi S, *et al.* The Republic of Indonesia Health
17 523 System Review. India: World Health Organization, 2017
18 524 <https://apps.who.int/iris/handle/10665/254716>.
19
20
21 525 17Alatas V, Banerjee A, Hanna R, Olken BA, Tobias J. Targeting the Poor: Evidence
22 526 from a Field Experiment in Indonesia. *American Economic Review* 2012; **102**:
23 527 1206–40.
24
25 528 18Noerdin E. Transport, health services and budget allocation to address maternal
26 529 mortality in rural Indonesia. *Transport and Communications Bulletin for Asia and*
27 530 *the Pacific* 2014; **84**: 1–14.
28
29 531 19Agustina R, Dartanto T, Sitompul R, *et al.* Universal health coverage in Indonesia:
30 532 concept, progress, and challenges. *The Lancet* 2018.
31
32 533 20BPJS Kesehatan. JKN coverage. 2020. <https://bpjs-kesehatan.go.id/bpjs/> (accessed
33 534 Oct 1, 2020).
34
35 535 21Jaspers L, Colpani V, Chaker L, *et al.* The global impact of non-communicable
36 536 diseases on households and impoverishment: a systematic review. *European Journal*
37 537 *of Epidemiology* 2015; **30**: 163–88.
38
39 538 22Lee JT, Hamid F, Pati S, Atun R, Millett C. Impact of noncommunicable disease
40 539 multimorbidity on healthcare utilisation and out-of-pocket expenditures in middle-
41 540 income countries: cross sectional analysis. *PLoS One* 2015; **10**: e0127199.
42
43 541 23Finkelstein EA, Chay J, Bajpai S. The economic burden of self-reported and
44 542 undiagnosed cardiovascular diseases and diabetes on Indonesian households. *PloS*
45 543 *one* 2014; **9**: e99572.
46
47 544 24Strauss J, Witoelar F, Sikoki B. The Fifth Wave of the Indonesia Family Life
48 545 Survey: Overview and Field Report: Volume 1. RAND Corporation, 2016
49 546 DOI:10.7249/WR1143.1.
50
51 547 25Strauss J, Witoelar F, Sikoki B, Wattie A. The fourth wave of the Indonesian
52 548 Family Life Survey (IFLS4): Overview and field report. RAND, 2009.
53
54 549 26Chobanian AV, Bakris GL, Black HR, *et al.* The seventh report of the joint
55 550 national committee on prevention, detection, evaluation, and treatment of high blood
56 551 pressure: the JNC 7 report. *Jama* 2003; **289**: 2560–2571.
57
58
59
60

- 1
2
3 552 27 Grundy SM, Cleeman JI, Merz CNB, *et al.* Implications of recent clinical trials for
4 553 the national cholesterol education program adult treatment panel III guidelines.
5 554 *Journal of the American College of Cardiology* 2004; **44**: 720–32.
- 6
7
8 555 28 Hussain MA, Huxley RR, Al Mamun A. Multimorbidity prevalence and pattern in
9 556 Indonesian adults: an exploratory study using national survey data. *BMJ open* 2015;
10 557 **5**: e009810.
- 11
12 558 29 World Health Organization. The Asia-Pacific perspective: redefining obesity and
13 559 its treatment. 2000.
- 14
15 560 30 Xu K, Evans DB, Kawabata K, Zeramdini R, Klavus J, Murray CJ. Household
16 561 catastrophic health expenditure: a multicountry analysis. *The Lancet* 2003; **362**:
17 562 111–7.
- 18
19
20 563 31 Organisation for Economic Co-operation and Development (OECD). Purchasing
21 564 power parities (PPP). OECD, 2019 <https://data.oecd.org/conversion/purchasing536>
22 565 [power-parities-ppp.htm](https://data.oecd.org/conversion/purchasing536) (accessed Sept 10, 2019).
- 23
24 566 32 Vaezghasemi M, Ng N, Eriksson M, Subramanian S. Households, the omitted level
25 567 in contextual analysis: disentangling the relative influence of households and
26 568 districts on the variation of BMI about two decades in Indonesia. *International*
27 569 *journal for equity in health* 2016; **15**: 102.
- 28
29
30 570 33 Lee ES, Forthofer RN. Analyzing complex survey data. Sage, 2006.
- 31
32 571 34 Hosseinpoor AR, Bergen N, Kunst A, *et al.* Socioeconomic inequalities in risk
33 572 factors for non communicable diseases in low-income and middle-income countries:
34 573 results from the World Health Survey. *BMC public Health* 2012; **12**: 912.
- 35
36 574 35 Manne-Goehler J, Atun R, Stokes A, *et al.* Diabetes diagnosis and care in sub-
37 575 Saharan Africa: pooled analysis of individual data from 12 countries. *The lancet*
38 576 *Diabetes & endocrinology* 2016; **4**: 903–12.
- 39
40
41 577 36 Field AE, Coakley EH, Must A, *et al.* Impact of overweight on the risk of
42 578 developing common chronic diseases during a 10-year period. *Archives of internal*
43 579 *medicine* 2001; **161**: 1581–6.
- 44
45 580 37 Wang HH, Wang JJ, Wong SY, *et al.* Epidemiology of multimorbidity in China
46 581 and implications for the healthcare system: cross-sectional survey among 162,464
47 582 community household residents in southern China. *BMC medicine* 2014; **12**: 188.
- 48
49
50 583 38 Mondor L, Maxwell CJ, Hogan DB, *et al.* Multimorbidity and healthcare
51 584 utilization among home care clients with dementia in Ontario, Canada: a
52 585 retrospective analysis of a population-based cohort. *PLoS medicine* 2017; **14**:
53 586 e1002249.
- 54
55 587 39 Deonisia A. Kemenkes akan memperkuat fungsi preventif dan promotif melalui
56 588 akreditasi Puskesmas. Kompas.id. 2019; published online Oct 28.
57 589 <https://kompas.id/baca/utama/2019/10/28/kemenkes-akan-memperkuat-fungsi->
58 590 [preventif-dan-promotif-melalui-akreditasi-puskesmas/](https://kompas.id/baca/utama/2019/10/28/kemenkes-akan-memperkuat-fungsi-) (accessed Sept 10, 2020).
- 59
60

- 1
2
3 591 40Hoffmann T, Jansen J, Glasziou P. The importance and challenges of shared
4 592 decision making in older people with multimorbidity. *PLoS medicine* 2018; **15**:
5 593 e1002530.
- 6
7
8 594 41 World Health Organization. Preliminary results: Rapid assessment of service
9 595 delivery for NCDs during the COVID-19 pandemic. World Health Organization,
10 596 2020 [https://www.who.int/publications/m/item/rapid-assessment-of-service-](https://www.who.int/publications/m/item/rapid-assessment-of-service-delivery-for-ncds-during-the-covid-19-pandemic)
11 597 [delivery-for-ncds-during-the-covid-19-pandemic](https://www.who.int/publications/m/item/rapid-assessment-of-service-delivery-for-ncds-during-the-covid-19-pandemic) (accessed Sept 10, 2020).
- 12
13 598 42 World Health Organization. Multimorbidity: Technical Series on Safer Primary
14 599 Care. Geneva, 2016.
- 15
16 600 43 Kernick D, Chew-Graham CA, O’Flynn N. Clinical assessment and management
17 601 of multimorbidity: NICE guideline. *Br J Gen Pract* 2017; **67**: 235–236.
- 18
19 602 44 Chandraratne NK, Pathirathna K, Harrison C, Siriwardena AN. A comparison of
20 603 policies and guidelines related to multimorbidity in the UK, Australia and Sri Lanka.
21 604 *Australian journal of general practice* 2018; **47**: 15–9.
- 22
23 605 45 Wang X, Sun X, Birch S, *et al.* People-centred integrated care in urban China. *Bull*
24 606 *World Health Organ* 2018; **96**: 843–52.
- 25
26 607 46 Satibi S, Andayani TM, Endarti D, Suwantara IPT, Wintariani NP, Agustini NPD.
27 608 Comparison of Real Cost Versus the Indonesian Case Base Groups (INA-CBGs)
28 609 Tariff Rates Among Patients of High-Incidence Cancers Under the National Health
29 610 Insurance Scheme. *Asian Pacific journal of cancer prevention: APJCP* 2019; **20**:
30 611 117.
- 31
32 612 47 Schröders J, Wall S, Hakimi M, *et al.* How is Indonesia coping with its epidemic of
33 613 chronic noncommunicable diseases? A systematic review with meta-analysis. *PloS*
34 614 *one* 2017; **12**.
- 35
36 615 48 Vellakkal S, Subramanian S, Millett C, Basu S, Stuckler D, Ebrahim S.
37 616 Socioeconomic inequalities in non-communicable diseases prevalence in India:
38 617 disparities between self-reported diagnoses and standardized measures. *PloS one*
39 618 2013; **8**: e68219.
- 40
41 619 49 D’Hoore W, Bouckaert A, Tilquin C. Practical considerations on the use of the
42 620 Charlson comorbidity index with administrative data bases. *Journal of clinical*
43 621 *epidemiology* 1996; **49**: 1429–33.

44
45
46
47
48
49 622
50
51
52
53
54
55
56
57
58
59
60

623 **Figure captions**624 **Figure 1. Prevalence of multimorbidity by age group and per capita household**
625 **expenditure**

626

627

628

629

630

631

632

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		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

633 **Table 2. Descriptive summary of health service use-financial burden and**
 634 **productivity outcomes by the number of NCDs (2014 IFLS)**
 635

	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				
<i>Outpatient services</i> ^{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
<i>Inpatient services</i> ^{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
<i>Catastrophic health expenditure</i> (%; 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% (0.6–2.5)	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				
<i>Labour participation</i> (%; 95% CI)				
50-60 years ^{d)}	84.3% (79.8–88.0)	74.3% (69.3–78.8)	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.

636

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)	9,400.36	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

638

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

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

642

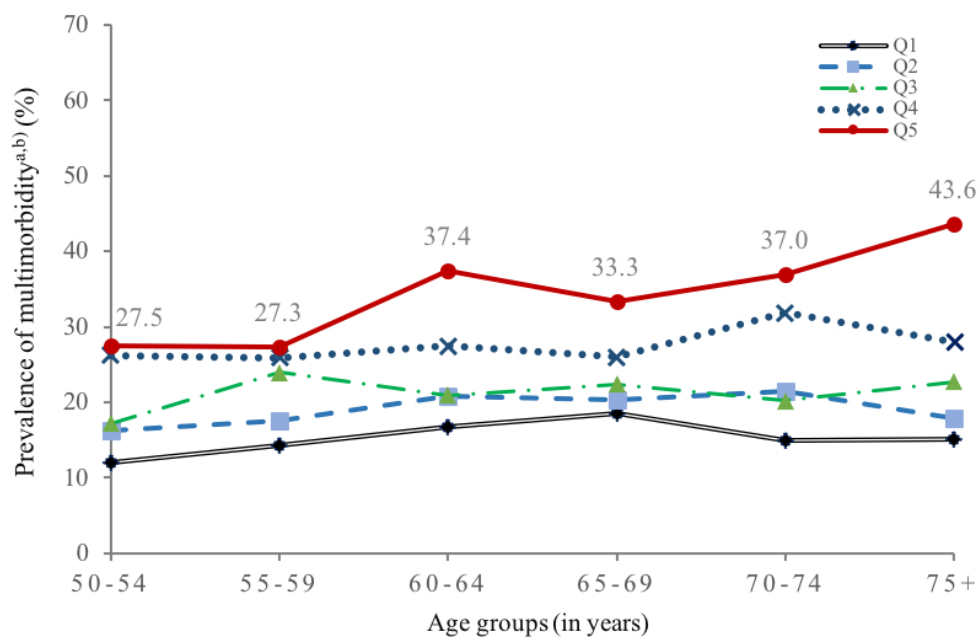


Figure 1. Prevalence of multimorbidity by age group and per capita household expenditure
 a) respondents who reported that they had 2 or more chronic conditions related to non-communicable diseases (NCDs). b) Pooled sample of Wave 4 and Wave 5. Q1-Q5 refer to household expenditure quintiles, where Q1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

137x91mm (150 x 150 DPI)

SUPPLEMENTAL MATERIAL

Figure S1. Sample flowchart

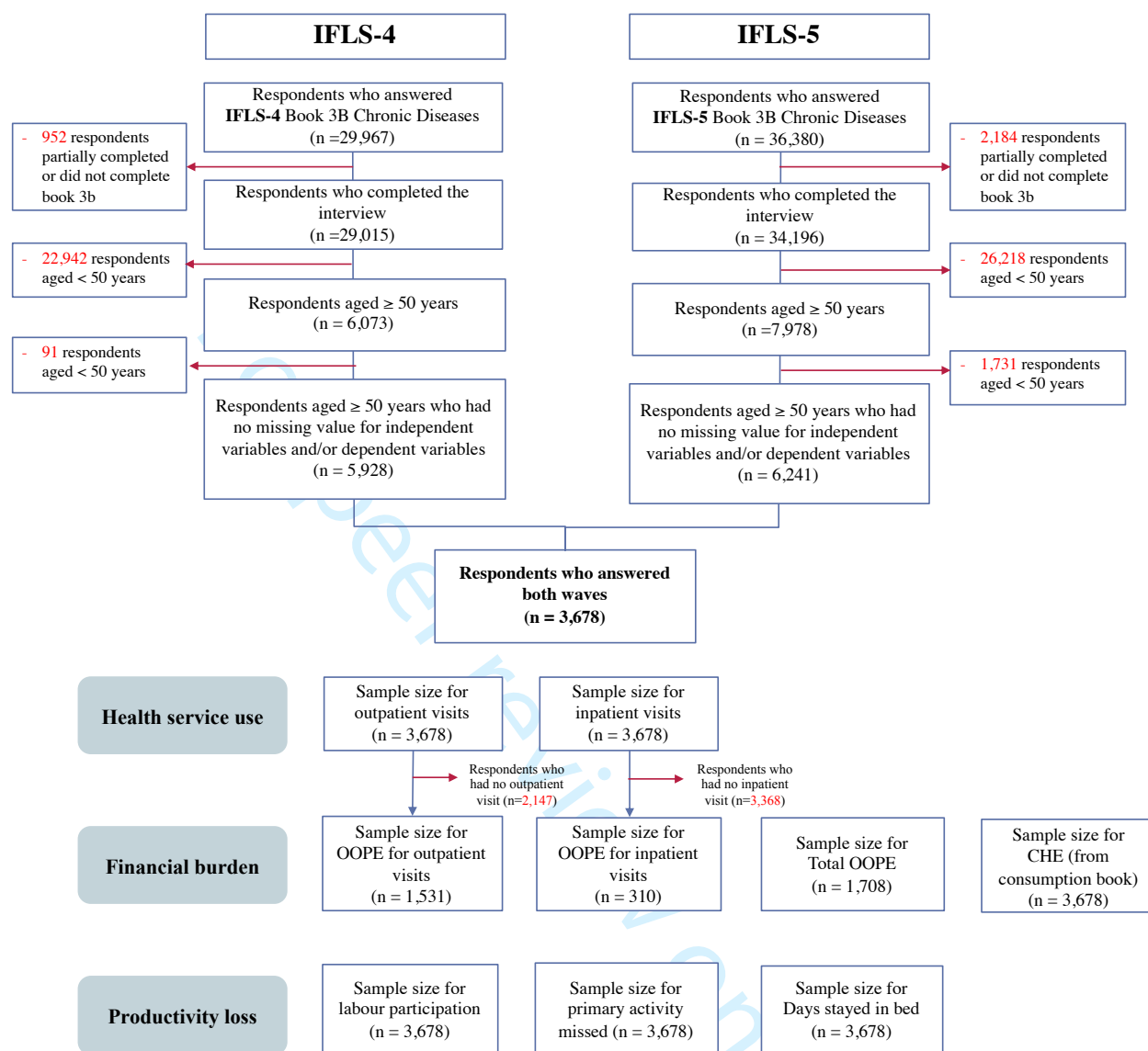


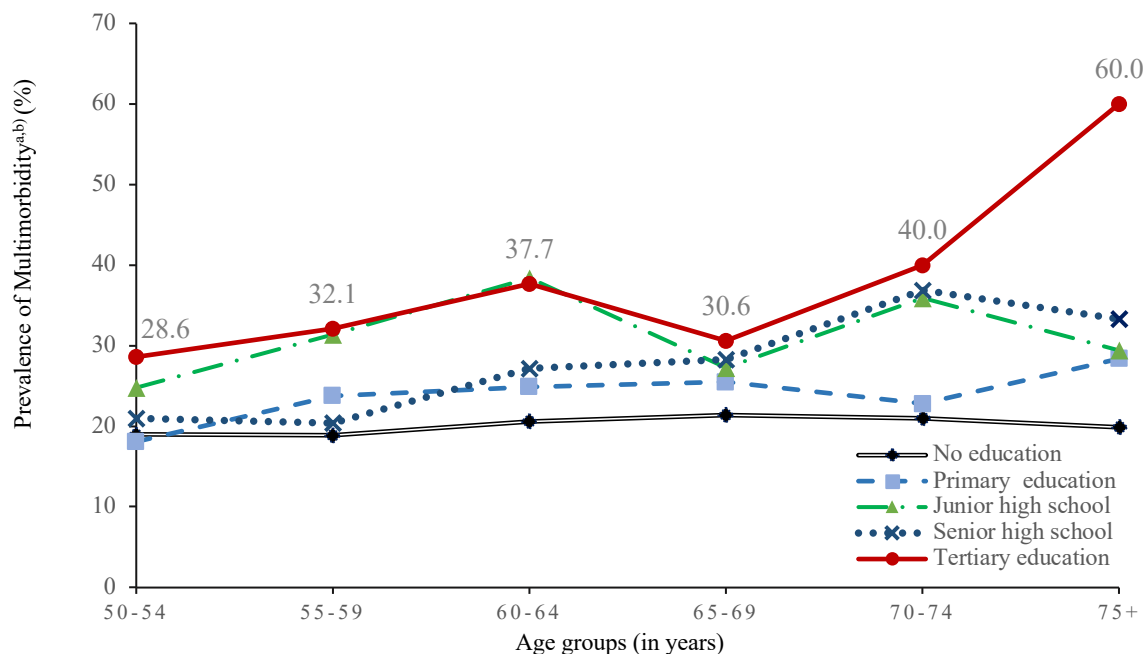
Table S1. List of variables for 2007 & 2014 IFLS analysis

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- <i>puskesmas</i> -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- <i>puskesmas</i> -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	

Variables	Type	Measurement	Source of measurement
Multimorbidity	Binary	5. 3+ NCDs	Book IIIB: CD06a – CD06r: Have a doctor/paramedic/nurse/ midwife ever told you that you had [list of chronic diseases]
		0. No	
		1. Yes (had 2 or more chronic conditions related to NCDs)	
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	Book IIIA: Age: How old are you?
		1. 50-59 years	
		2. 60-69 years	
		3. 70-79 years	
		4. 80+	
Sex	Binary	0. Male	Book IIIA: Sex: (identified by interviewers)
		1. Female	
Ethnicity	Categorical nominal	0. Javanese	
		1. Sundanese	
		2. Others	
Marital status	Binary	0. Unmarried/Divorce	Book IIIA HR00b: Are you currently married?
		1. Married or living together	
Education	Categorical ordinal	0. None	Book IIIA: DL06: What is the highest education level attended? DL07: What is the highest grade completed at school.
		1. Elementary school	
		2. Junior high school	
		3. High school	
		4. Tertiary	
Occupation	Categorical nominal	0. None	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?
		1. Casual worker	
		2. Self-employed	
		3. Government/private worker	
Health insurance status	Binary	0. Uninsured (Not covered by any insurance)	Book IIIB: AK01: Are you the policy holder/primary beneficiary of health benefits-health insurance?
		1. Insured	
Per capita expenditure	Categorical ordinal	0. Q1 (lowest)	Book KS
		1. Q2	
		2. Q3	
		3. Q4	
		4. Q5 (highest)	
Residency	Binary	0. Rural	Book T-2: SC06: (identified by interviewers)
		1. Urban	
Region	Categorical nominal	0. Java-Bali	Book T-2: SC01: province (identified by interviewers)
		1. Sumatra	
		2. Nusa Tenggara	
		3. Kalimantan	
		4. Sulawesi	

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 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)

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

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)	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 (4.0, 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 (5.2, 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

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 aOR (95% CI)	Number of visits IRR (95% CI)	Any visit aOR (95% CI)	Number of visits 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

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

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

Variables	Productivity loss		
	Labour participation aOR (95% CI)	Days primary activity missed IRR (95% CI)	Days stayed in bed 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		0.55*** (0.49–0.63)	0.33*** (0.26–0.42)
Government/private	n/a	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

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

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 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	1.12 (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

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

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 d/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) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up (b) <i>Case-control study</i> —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 (c) <i>Cross-sectional study</i> —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

	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) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —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

	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) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)		N/A
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time		N/A
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure		N/A
		<i>Cross-sectional study</i> —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				

	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.

BMJ Open

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

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-041870.R2
Article Type:	Original research
Date Submitted by the Author:	21-Jan-2021
Complete List of Authors:	<p>Marthias, Tiara; The University of Melbourne, Nossal Institute for Global Health; Gadjah Mada University, Department of Public Health, Faculty of Medicine, Public Health and Nursing</p> <p>Anindya, Kanya; The University of Melbourne, Nossal Institute for Global Health</p> <p>Ng, Nawi ; University of Gothenburg, Department of Public Health and Community Medicine</p> <p>McPake, Barbara; The University of Melbourne, Nossal Institute for Global Health</p> <p>Atun, Rifat; Harvard University T H Chan School of Public Health, Department of Global Health and Population</p> <p>Arfyanto, Hafiz ; SMERU Research Institute</p> <p>Hulse, Emily ; The University of Melbourne, Centre for Health Policy, School of Population and Global Health</p> <p>Zhao, Yang; The University of Melbourne, Nossal Institute for Global Health, The University of Melbourne; Peking University Health Science Centre, The George Institute for Global Health</p> <p>Jusril, Hafizah; Universitas Indonesia, Center for Health Research</p> <p>Pan, Tianxin; The University of Melbourne, Center for Health Policy, School of Population and Global Health</p> <p>Ishida, Marie; The University of Melbourne, Nossal Institute for Global Health</p> <p>Lee, John; The University of Melbourne, Nossal Institute for Global Health; Imperial College London, Department of Primary Care and Public Health, School of Public Health</p>
Primary Subject Heading:	Health policy
Secondary Subject Heading:	Public health, Health policy, Health economics
Keywords:	PUBLIC HEALTH, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health economics < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60





I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

4
5 Tiara Marthias^{†1,2}, Kanya Anindya^{†*1}, Nawi Ng³, Barbara McPake¹, Rifat Atun⁴, Hafiz
6 Arfyanto⁵, Emily S G Hulse⁶, Yang Zhao^{1,7}, Hafizah Jusril⁸, Tianxin Pan⁶, Marie
7 Ishida¹, John Tayu Lee^{1,9}

8
9 **Affiliations**

10 ¹Nossal Institute for Global Health, The University of Melbourne, Melbourne, Australia
11 ²Department of Public Health, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah
12 Mada, Yogyakarta, Indonesia ³Department of Public Health and Community Medicine, University
13 of Gothenburg, Sweden ⁴Department of Global Health and Population, Harvard T.H. Chan School
14 of Public Health, Harvard University, Boston, MA, USA ⁵SMeRU Research Institute, Jakarta,
15 Indonesia ⁶Center for Health Policy, School of Population and Global Health, The University of
16 Melbourne, Melbourne, Australia ⁷The George Institute for Global Health, Peking University
17 Health Science Center, Beijing, China ⁸Center for Health Research, Faculty of Public Health,
18 Universitas Indonesia, Depok, Indonesia ⁹Department of Primary Care and Public Health, School
19 of Public Health, Imperial College London, United Kingdom

20
21 [†] Co-first author (both contributed equally)

22 ^{*} Corresponding author

23 Postal address: The Nossal Institute for Global Health, level 5, 333 Exhibition Street,
24 Melbourne, Victoria 3010 Australia.

25 E-mail address: kanindya@student.unimelb.edu.au

26 Telephone number: +62 878 9966 9201

27 **Word count:** 4014

1
2
3 29 **Abstract**
4

5 30 **Objectives** To examine noncommunicable diseases (NCDs) multimorbidity level and
6
7
8 31 its relation to households' socioeconomic characteristics, health service use,
9
10 32 catastrophic health expenditures, and productivity loss.
11

12 33
13
14 34 **Design** This study utilised panel data of the Indonesian Family Life Survey (IFLS)
15
16
17 35 conducted in 2007 (Wave 4) and 2014 (Wave 5).
18

19 36
20
21 37 **Setting** The original sampling frame was based on 13 out of 27 provinces in 1993,
22
23
24 38 representing 83% of the Indonesian population.
25

26 39
27
28 40 **Participants** We included respondents aged 50 years and above in 2007, excluding
29
30
31 41 those who did not participate in both Waves 4 and 5. The total number of participants
32
33 42 in this study are 3,678 respondents.
34

35 43
36
37 44 **Primary outcome measures** We examined three main outcomes; health service use
38
39
40 45 (outpatient and inpatient care), financial burden (catastrophic health expenditure), and
41
42 46 productivity loss (labour participation, days primary activity missed, days confined in
43
44
45 47 bed). We applied multilevel mixed-effects regression models to assess the associations
46
47 48 between NCD multimorbidity and outcome variables,
48

49 49
50
51 50 **Results** Women were more likely to have NCD multimorbidity than men and the
52
53
54 51 prevalence of NCD multimorbidity increased with higher socioeconomic status. NCD
55
56 52 multimorbidity was associated with a higher number of outpatient visits (compared
57
58 53 with those without NCD, incidence rate ratio [IRR] 4.25, 95% CI 3.33–5.42 for
59
60

1
2
3 54 individuals with >3 NCDs) and inpatient visits (IRR 3.68, 95% CI 2.21–6.12 for
4
5 55 individuals with >3 NCDs). NCD multimorbidity was also associated with a greater
6
7 56 likelihood of experiencing catastrophic health expenditure (for >3 NCDs, adjusted odds
8
9 ratio [aOR] 1.69, 95% CI 1.02–2.81) and lower participation in the labour force (aOR
10
11 57
12 58 0.23, 95% CI 0.16–0.33) compared with no NCD.

13
14
15 59

16
17 60 **Conclusions** NCD multimorbidity is associated with substantial direct and indirect
18
19 61 costs to individuals, households, and the wider society. Our study highlights the
20
21 62 importance of preparing health systems for addressing the burden of multimorbidity in
22
23 63 LMICs.

24
25
26 64

27
28 65 **Keywords** Multimorbidity, Indonesia, noncommunicable diseases, health service use,
29
30 66 catastrophic health expenditure, productivity loss.

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.

67

68 Introduction

69 Noncommunicable diseases (NCDs) continue to be the leading cause of global burden
70 of diseases, with 78% of NCD-related mortality concentrated in low-income and
71 middle-income countries (LMICs).¹ The current COVID-19 pandemic highlights that
72 the presence of NCDs can increase the fatality risk of a communicable disease.²
73 Indonesia, the third most populous country among LMICs (after China and India) with
74 a population of 273 million, has seen rapid demographic and epidemiological
75 transitions over the last few decades. The threat of NCDs is expected to rise with the
76 aging population (population aged 65 or above), which is projected to account for a
77 quarter of the population by 2070.³ Concurrently, the prevalence of NCD
78 multimorbidity, defined as the presence of two or more NCDs, is expected to rise
79 rapidly in many LMICs, as both life expectancy and exposure to risk factors increase.⁴
80 Indonesia has started recognising the burden of NCDs due to its substantial contribution
81 to the top causes of death and disability-adjusted life years (DALYs).⁵ However, current
82 Indonesia health programs remain limited to curative services, focusing on single

1
2
3 83 chronic disease as opposed to assessing and mitigating the impact of multimorbidity on
4
5 84 the individual, health system, and wider society.
6
7
8 85

9
10 86 COVID-19 pandemic emphasises the importance of health systems responsiveness to
11
12 87 multimorbidity. Historically, the growing burden of multimorbidity in LMICs was
13
14 88 highlighted in the United Nations High-Level Meetings on NCDs in 2011, 2014, and
15
16
17 89 2018.⁶ LMICs typically have low levels of government expenditure for health and
18
19 90 inadequate health insurance coverage, which often results in higher levels of out-of-
20
21 91 pocket expenditure (OOPE) and risk of impoverishing patients with chronic health
22
23 92 conditions.^{7,8} The economic burden of multimorbidity is further compounded by the
24
25
26 93 fact that multiple healthcare specialists typically manage multimorbid patients in
27
28 94 LMICs.⁹ This leads to inefficiencies with numerous different hospital visits,
29
30 95 polypharmacy, and suboptimal disease management.^{9,10}
31
32

33 96
34
35 97 While the Indonesian health system is mainly funded by the government, it only spends
36
37 98 around 2% of its GDP on health, which is significantly lower than other LMICs with
38
39 99 comparable income level.¹¹ Approximately half of all health spending is covered by the
40
41 100 public sector and one-third comes from OOP payment.¹² While the primary health care
42
43 101 (PHC) centres are designed as gatekeepers for primary prevention for NCDs, studies
44
45 102 have found limited capacity of PHC in proper management of NCDs.^{13–15} There is also
46
47 103 high public funding allocations to curative services at the hospital-level,¹⁶ with limited
48
49 104 investment in preventive and promotive health services.¹² Further, the poor and those
50
51 105 living in limited-resource regions have generally lower hospital utilisation due to
52
53
54 106 geographical barriers and high transportation costs.^{17,18} Low overall government health
55
56
57
58
59
60

1
2
3 107 spending, coupled with limited investment in PHC and the high burden of NCDs may
4
5 108 further increase the high OOPE in Indonesia and inequitable access to care.⁵
6
7
8 109

9
10 110 The Indonesian national health insurance program expansion in 2014 was designed to
11
12 111 achieve universal coverage by 2019.¹⁹ However, as of August 2020, the insurance
13
14 112 coverage was only at 85.5%,²⁰ leaving around 40 million people remained uncovered.
15
16 113 Furthermore, the insurance program has been in funding deficit since its inception and
17
18 114 recent studies identified that it may not be financially sustainable.^{1,2} Further, NCDs
19
20 115 were responsible for around 60% of total spending of the insurance program. Therefore,
21
22 116 addressing NCDs through preventive and promotive programs is pertinent to strengthen
23
24 117 the Indonesian health system and the sustainability of its health insurance program.
25
26 118

27
28
29
30 119 Evidence from high-income countries (HICs) has found that apart from the negative
31
32 120 impact on health outcomes, multimorbidity imposes substantial economic costs on
33
34 121 individuals and households. This is because patients with multimorbidity incur large
35
36 122 medical expenditures and are more likely to be absent from work.^{8,21,22} However, there
37
38 123 is no previous study in Indonesia that has examined the economic burden of NCD
39
40 124 multimorbidity, as earlier studies have focused on the burden of a single NCD.²³ Results
41
42 125 from this study may inform health systems reform across the region and be applicable
43
44 126 to similar LMICs. We present the first study that uses longitudinal data to examine
45
46 127 NCD multimorbidity levels, and their relationship to households' socioeconomic
47
48 128 characteristics, health service use, catastrophic health expenditures, and productivity
49
50 129 loss.
51
52
53
54
55

56 130

57
58 131
59
60

1
2
3 132 **Methods**

4
5 133 **Sample and data**

6
7
8 134 We utilised panel data from two waves of the Indonesian Family Life Survey (IFLS)
9
10 135 conducted in 2007 (Wave 4) and 2014 (Wave 5). IFLS is an ongoing longitudinal
11
12 136 survey that started in 1993 with four subsequent rounds of data collection (1997/1998,
13
14 137 2000, 2007/2008, and 2014/2015). The original sample was based on 13 out of 27
15
16 138 provinces in 1993, representing 83% of the population. Wave 5 was conducted between
17
18 139 September 2014–March 2015, with 76% re-contact rate from the main respondents of
19
20 140 Wave 1. The dataset contains information at the individual- and household-level,
21
22 141 including sociodemographic characteristics, healthcare utilisation and expenditure, and
23
24 142 labour participation. The objectives and methods of the IFLS are detailed
25
26 143 elsewhere.^{24,25} This study included respondents aged 50 years and above in 2007 who
27
28 144 participated in both Waves 4 and 5, and excluded those with missing values for the
29
30 145 study variable. Our final sample is 3,678 respondents and a sample flowchart is
31
32 146 presented in Figure S1.
33
34
35
36
37

38 147 **Variables**

39
40
41 148 **Multimorbidity**

42
43 149 Our main variable of interest was NCD multimorbidity. Fourteen types of NCDs were
44
45 150 included in Wave 5, but only 10 NCDs in Wave 4. For consistency, our main analysis
46
47 151 used 10 NCDs that were available in both waves, as the following: hypertension,
48
49 152 diabetes, asthma, heart attack/coronary heart diseases, liver disease, stroke, cancer,
50
51 153 arthritis/rheumatism, hypercholesterolemia, and depression/mental illness. The four
52
53 154 NCDs that were only included in Wave 5 were: prostate diseases, kidney diseases
54
55 155 (excluding malignancy), digestive diseases, and memory-related diseases.
56
57
58
59
60

1
2
3 157 NCD status was either identified through self-reporting or physical examination. In the
4
5 158 self-report section, respondents who answered affirmatively to the question, “Has a
6
7 159 doctor/paramedic/nurse/midwife ever told you that you had any of these conditions?”,
8
9 160 were defined as reporting an NCD. For hypertension and hypercholesterolemia, the
10
11 161 diagnoses were confirmed through a physical examination conducted by trained nurses,
12
13 162 i.e. blood pressure and total cholesterol levels. All IFLS respondents aged 15 years and
14
15 163 older had their blood pressure recorded three times on alternate arms using Omron self-
16
17 164 inflating sphygmomanometers by trained nurses.^{24,25} In our analysis, a respondent was
18
19 165 categorised as having hypertension if the mean measurement of systolic blood pressure
20
21 166 was 140 mm Hg and/or mean diastolic blood pressure was 90 mm Hg or the respondent
22
23 167 self-reported having been diagnosed with hypertension.²⁶ We also included
24
25 168 hypercholesterolemia, defined as total blood cholesterol value 240 mg/dl, as
26
27 169 morbidity.²⁷ It is important to note that different measurements of hypercholesterolemia
28
29 170 were used in Wave 4 and 5. Blood test for total cholesterol was performed in Wave 4
30
31 171 as opposed to self-reporting of hypercholesterolemia in Wave 5.
32
33
34
35
36
37
38
39
40

41 173 A total of 10 NCDs were used to quantify the number of NCDs (0, 1, 2, 3 or more) and
42
43 174 respondents with two or more NCDs were categorised as having multimorbidity (0 or
44
45 175 1). Previous studies have typically considered hypertension, obesity, and
46
47 176 hypercholesterolemia as risk factors of NCDs and their inclusion in the multimorbidity
48
49 177 clustering remains inconsistent.^{23,28} Therefore, in the sensitivity analysis, we included
50
51 178 obesity, defined as having BMI ≥ 25 kg/m², in the clustering of multimorbidity.²⁹ All
52
53 179 statistical analyses were conducted using STATA 13.0.
54
55
56
57
58
59
60

1
2
3 182 ***Outcome variables***
4

5 183 The three main outcomes are: health service use and financial burden as the direct cost
6
7 184 and productivity loss as the indirect cost of multimorbidity. Respondents were asked
8
9 185 about the number of outpatient visits (in the last four weeks) and inpatient visits (in the
10
11 186 last 12 months) and OOPE. The data on OOPE was also collected with four weeks and
12
13 187 12 months recall period for outpatient and inpatient visits, respectively. We calculated
14
15 188 the total annual OOPE by multiplying OOPE for outpatient visits with 13 (as the
16
17 189 reference period of outpatient expenditure in the IFLS is four weeks and a year consists
18
19 190 of 52 weeks), and added OOPE for inpatient visits. The total OOPE reflects all costs
20
21 191 associated with outpatient or inpatient visits, including medication, medical
22
23 192 consultation, and laboratory tests.
24
25
26
27
28
29

30
31 194 Catastrophic health expenditure occurs when OOPE exceeds certain thresholds of a
32
33 195 household's expenditure. The thresholds used in this study were 10% and 25% of total
34
35 196 household expenditure (as proposed by the Sustainable Development Goal 3 targets),
36
37 197 and the WHO's recommendation at 40% of household's capacity to pay. Capacity to
38
39 198 pay is defined as the household's ability to pay for other expenses, including medical
40
41 199 costs, after having household subsistence needs met.³⁰ Household subsistence needs are
42
43 200 proxied by the household non-food expenditure variable. Catastrophic health
44
45 201 expenditure ($cata_h$) occurrence is expressed as follows:
46
47
48

49
50 202
$$cata_h = 1 \text{ if } \frac{HS_h}{THE_h} \text{ or } \frac{HS_h}{CTP_h} > z, \text{ and otherwise is zero.}$$

51

52
53 203 Where HS_h is the total OOPE for health, THE_h is the total household expenditure, CTP_h
54
55 204 is capacity to pay, and z is the threshold of capacity to pay. In using the proportion of
56
57 205 total OOPE for health to total household expenditure (THE), the threshold z was set at
58
59 206 10% and 25%. Further, in using the proportion of OOPE for health to capacity to pay

1
2
3 207 (CTP), the threshold z was set at 40%. All monetary values were adjusted for inflation
4
5 208 and converted to 2014 International Dollars.³¹
6
7
8 209

9
10 210 Productivity loss was assessed based on: (1) labour participation; (2) the number of
11
12 211 days of primary activity missed due to poor health; and (3) number of days confined to
13
14 212 bed. Labour participation status was defined as the respondent's employment status at
15
16 213 the time of the survey. The number of days of primary daily activity missed and days
17
18 214 confined to bed were included in the health conditions section of the survey, with a four
19
20 215 week recall period.
21
22
23
24 216

25 26 217 ***Covariates***

27
28 218 Sociodemographic factors included were: sex, age groups (50-60, 61-70, above 70
29
30 219 years), marital status (currently and not currently married), education (no education,
31
32 220 primary, junior high school, senior high school, tertiary), ethnicity (Javanese,
33
34 221 Sundanese, others), coverage of health insurance (no, yes), type of work (unemployed,
35
36 222 casual, self-employed, government/private), and respondents' economic status (per
37
38 223 capita expenditure for consumption). The economic status was categorised into
39
40 224 quintiles: q1 (lowest) to q5 (highest). We also included residency (rural, urban), region
41
42 225 of residency (Java-Bali, Sumatra, Nusa Tenggara, Kalimantan, Sulawesi), and period
43
44 226 (using wave 2007 as the reference group) as covariates. Detailed definitions and
45
46 227 categorisations are available in Table S1. It should be noted that IFLS did not include
47
48 228 the eastern regions which are considered to be underdeveloped.
49
50
51
52
53
54 229

230 **Statistical analysis**

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

248 **Patient and public involvement**

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

250

251 **Results**

252 **Descriptive statistics**

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

1
2
3 255 female, 74.4% were married, 16.5% had at least secondary education level or above
4
5 256 and only 25.5% had health insurance coverage. In 2014, the median age was 65 years
6
7 257 (IQR 60–72), and health insurance coverage increased to 42.8%.
8
9

10 258

11
12 259 A similar prevalence of NCD multimorbidity was observed between 2007 (21.0%, 95%
13
14 260 CI 19.6–22.6) and 2014 (22.0%, 95% CI 20.6–23.6). The prevalence of multimorbidity
15
16 261 increased with rising socioeconomic status. For example, in 2014, the prevalence
17
18 262 increased from 18.0% (95% CI 16.9–20.7) to 41.2% (95% CI 31.6–51.6) between
19
20 263 respondents with no education and those with tertiary education. Similarly, the
21
22 264 prevalence increased from 13.5% (95% CI 11.1–16.2) to 36.2% (95% CI 32.2–40.5)
23
24 265 between the lowest and highest wealth quintiles. The trend of increasing multimorbidity
25
26 266 was observed for all age groups, shown in Figure 1, where the fifth and fourth wealth
27
28 267 quintiles had a higher prevalence of NCD multimorbidity than the lower quintiles. The
29
30 268 prevalence of multimorbidity by level of education is available in Figure S2.
31
32

33 269

34
35
36
37 270 The regression results show that NCD multimorbidity was more likely among those
38
39 271 with higher socioeconomic status (Table 1). Respondents in the highest wealth quintile
40
41 272 were more likely to report NCD multimorbidity, compared with those in the lowest
42
43 273 quintile (aOR 2.22, 95% CI 1.72–2.86). Compared with those with lower educational
44
45 274 attainment, respondents with higher educational attainment were more likely to
46
47 275 experience NCD multimorbidity (aOR 1.54, 95% CI 1.01–2.34 for tertiary level
48
49 276 completed). Additionally, the prevalence of multimorbidity was higher in females than
50
51 277 males (aOR 1.74, 95% CI 1.46–2.08) and those living in urban areas (aOR 1.41, 95%
52
53 278 CI 1.19–1.67). The ICC shows that above 53% ($1 - [0.34 + 0.13]$) of the variance can be
54
55 279 ascribed to between-individual level differences (Table S3).
56
57
58
59
60

280 **Multimorbidity and health service use**

281 The probability of using outpatient and inpatient care and the number of visits increased
282 with more NCD diagnoses (Table 2, Table 3). Respondents with a single NCD were
283 1.35 times more likely (95% CI 1.15–1.58) to have experienced an outpatient visit in
284 the past four weeks compared with those without an NCD. The odds of an outpatient
285 visit increased to 4.66 times (95% CI 3.55–6.11), while the incidence rate increased by
286 4.25 times (95% CI 3.33–5.42) in those with three or more NCDs. Furthermore, the
287 incidence of inpatient visits was 3.68 times (95% CI 2.21–6.12) higher in those with
288 three or more NCDs, compared with those without an NCD.

289
290 We reported the results of ICC in Table S3. We found that 14% and 11% of the variance
291 in the outpatient visit were attributable to the differences within-individuals and
292 households, respectively. Between-individual variation accounted for the largest
293 variation, where it explained 75% (1-[0.14+0.11]) and 65% (1-[0.25+0.12]) of
294 outpatient and inpatient visit, respectively. No influence of district-level variables was
295 found (ICC=0).

297 **Multimorbidity and financial burden**

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

1
2
3 305 presents the proportion of respondents with catastrophic health expenditure using
4
5 306 different thresholds. The results using 10% and 25% of THE, and 40% of non-food
6
7 307 consumption thresholds found that households with more than two NCDs had a higher
8
9 308 proportion of catastrophic health expenditure compared with households without any
10
11 309 member having any NCDs.
12
13
14

15 310

16
17 311 Table 4 presents the logistic regression results for the proportion of respondents who
18
19 312 experienced catastrophic health expenditure using different thresholds. At 10% of THE
20
21 313 as the threshold, having two NCDs increases the odds of catastrophic health
22
23 314 expenditure to 1.58 times (95% CI 1.06–2.35), compared with having no NCD. These
24
25 315 odds increased to 1.69 times for those having three NCDs or more (95% CI 1.02–2.81).
26
27 316 At 25% and 40% thresholds, we found no significant association between the number
28
29 317 of NCD and the incidence of catastrophic health expenditure.
30
31
32

33 318

34 319 **Multimorbidity and productivity loss**

35
36
37 320 More NCDs diagnoses were associated with greater productivity loss (Table 2, Table
38
39 321 5). For example, among those aged 50–60 years old, only 49.8% (95% CI 36.7–62.9)
40
41 322 of respondents with three or more NCDs were employed, compared with 84.3% (95%
42
43 323 CI 79.8–88.0) of respondents without NCD (Table 2). The mean number of days of
44
45 324 primary daily activity missed increased from 2.7 days (SD \pm 6.0), for those without any
46
47 325 NCDs, to 10.1 days (SD \pm 12.1) for those with three or more NCDs. The mean number
48
49 326 of days confined to bed also increased among those with three or more NCDs.
50
51
52

53 327

54
55
56
57 328 Individuals diagnosed with three or more NCDs were 0.23 times less likely (95% CI
58
59 329 0.16–0.33) to be employed compared with those without NCD (Table 5). Compared

1
2
3 330 with those without NCD, being diagnosed with three or more NCDs were expected to
4
5 331 have a higher incidence rate of missing days of primary activity (IRR 2.59, 95% CI
6
7 332 1.97–3.41) as well as days confined in bed (IRR 2.64, 95% CI 1.60–4.36). We found
8
9 333 that 48% of the variance in labour participation was due to within-individual variations,
10
11 334 while between-individual variation accounted for 23% (1-[0.48+0.28+0.01]) (Table
12
13 335 S3).

336

337 **Robustness check**

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

346

347 **Discussion**

348 Our study provides the first comprehensive analysis of multimorbidity in Indonesia
349 using the only large panel dataset in Indonesia. Our study reveals that almost one in
350 four of our study population has at least two NCDs, with 6.5% having three or more in
351 2014. Our findings show a higher prevalence of multimorbidity in wealthier population
352 groups. Multimorbidity was associated with a higher use of healthcare services, higher
353 probability of catastrophic health expenditure, and a reduction in productivity.

1
2
3 354
4
5

6 355 Analyses of socioeconomic gradients of NCDs in HICs routinely find negative
7
8 356 socioeconomic gradients. However, this is not the case for LMICs, which have a more
9
10 357 mixed pattern of the distribution of risk factors.^{34,35} Other studies find a similar pattern
11
12 358 with diabetes and cardiovascular diseases in LMICs undergoing epidemiological
13
14 359 transition.³⁵ These conditions predominate in high-income quintiles in early stages of
15
16 360 transition, which may explain our findings on the higher prevalence of NCD
17
18 361 multimorbidity among more affluent population. We also found that obesity was more
19
20 362 prevalent in wealthier quintiles. As obesity is associated with several NCDs
21
22 363 (cardiovascular diseases, hypertension, stroke, cancer, arthritis and
23
24 364 hypercholesterolemia),³⁶ this may explain our findings on socioeconomic gradients of
25
26 365 NCDs. Further, our results on socioeconomic patterning of multimorbidity can be
27
28 366 explained by the fact that higher-income and higher-educational groups have better
29
30 367 health literacy and access to healthcare services and thus, are more likely to have NCDs
31
32 368 diagnosed than lower socio-income groups.
33
34
35
36
37
38
39

40 370 Our findings showing the association between having more NCDs and greater use of
41
42 371 health services are in line with earlier studies from both HICs and LMICs.^{9,28,37} The
43
44 372 presence of NCD multimorbidity was also associated with a greater financial burden,
45
46 373 which is mainly driven by higher healthcare use. These findings are consistent with
47
48 374 earlier studies.^{10,28,37,38} Based on a previous Indonesian study, four NCDs
49
50 375 (hypertension, diabetes, heart problems, and stroke) are the leading causes of mortality
51
52 376 and were estimated to account for 12% of Indonesia's OOPE in 2020.²² Furthermore,
53
54 377 the impoverishment effect of multimorbidity has been previously documented and is
55
56 378 confirmed in our study.^{7,21,22,37}
57
58
59
60

1
2
3 379
4

5 380 This study contributes to the growing evidence that multimorbidity has a substantial
6
7 381 impact on disability and productivity.^{7,9,22} Interventions that can help effectively
8
9 382 prevent and manage multimorbidity have the potential for generating substantial returns
10
11 383 on improved health, work productivity and social benefits. However, a large portion of
12
13 384 the Indonesia government health expenditure is still geared towards curative care.⁵
14
15 385 Renewing the focus on health promotion and NCD prevention requires a strong PHC
16
17 386 system.⁹ PHC is the entry point of a sustainable health system for the early detection of
18
19 387 risk factors and initiation of a treatment-seeking pathway for patients with NCDs, and
20
21 388 thus, plays a crucial role for NCD prevention and provision of long-term integrated
22
23 389 care. Such policies would be in line with the current program of the Ministry of Health
24
25 390 in Indonesia to reorient public PHC to provide more promotive and preventive health
26
27 391 services, such as through the implementation of Chronic Diseases Management
28
29 392 Program (Prolanis) in PHC.^{12,39} However, the participation in this program remains low
30
31 393 due to the poor access to PHC facilities, especially in non-Java-Bali regions. Engaging
32
33 394 the private sector, which makes up 60% of health facilities in Indonesia, is warranted
34
35 395 to expand the coverage of NCDs promotive and prevention activities.⁴⁰ Furthermore,
36
37 396 the development of digital health solution and telehealth for NCDs prevention and
38
39 397 control should be included in the national plan.⁴¹
40
41
42
43
44
45
46
47
48
49

398

50 399 Although most countries and international health organisations have recognised the
51
52 400 importance of multimorbidity,⁴² most health policies and programs still focus on single
53
54 401 diseases, including in Indonesia. Therefore, the health systems need to shift from
55
56 402 single-disease models to new financing methods and service delivery to more
57
58 403 effectively manage multimorbidity.^{43,44} At the primary health care level, this can be
59
60

1
2
3 404 done through improved prevention and treatment of multimorbidity, underpinned by
4
5 405 multidisciplinary teams led by general practitioners.⁴² There is also a need to strengthen
6
7 406 the coordination of patient management between primary and secondary care. Similar
8
9 407 to many LMICs and neighbouring countries in Asia, healthcare delivery in Indonesia
10
11 408 remains fragmented and hospital-centred, with little coordination among healthcare
12
13 409 providers across different tiers of the system.⁴⁵
14
15
16

17 410

18
19 411 Furthermore, under the current national health insurance scheme, the hospital
20
21 412 reimbursement system that uses case-based groups has created significant gaps between
22
23 413 reimbursable costs and actual hospital expenses.⁴⁶ The reimbursement system, which
24
25 414 is mainly based on primary diagnosis, limits the hospital's capacity and willingness to
26
27 415 treat complicated cases such as those with multimorbidity.⁴⁷ Thus, while clinical
28
29 416 guideline for single NCD still has a prominent role, it also important for LMICs to
30
31 417 develop a clinical guideline for multimorbidity, along with payment systems that would
32
33 418 ensure quality health services at both primary and secondary levels of care for patients
34
35 419 with multimorbidity.^{9,40} It is also worth noting that Indonesia is still facing the double
36
37 420 burden of infectious and chronic diseases. Therefore, multimorbidity care delivery
38
39 421 model needs to pay attention to the management of NCDs alongside infectious diseases.
40
41
42
43
44
45
46
47

48 422

49 423 There are several limitations to our study. First, the IFLS-5 was conducted between
50
51 424 2014 and 2015, which may not be able to capture the current prevalence of
52
53 425 multimorbidity in Indonesia. Despite this limitation, IFLS is the only longitudinal
54
55 426 survey available in Indonesia that is useful to produce more accurate estimates
56
57 427 compared with using a cross-sectional dataset (e.g. the National Socioeconomic
58
59 428 Survey). Second, our findings should be interpreted with caution since the assessment
60

1
2
3 429 of NCDs was mostly based on self-reporting. This may cause misreporting of the true
4
5 430 diagnoses and prevalence of multimorbidity. The health service use and OOPE were
6
7 431 also based on self-reporting and may be prone to recall bias.⁴⁸ The use of self-reported
8
9 432 diagnoses limits our assessment of the actual severity of the diseases, which may vary
10
11 433 across socioeconomic status. Future studies should consider using different datasets
12
13 434 (such as clinical dataset from the hospital) and applying clinical metrics such as
14
15 435 Charlson index, which could more objectively capture disease severity and predict the
16
17 436 health outcomes.⁴⁹ Third, the IFLS sample did not include eastern Indonesia. There is
18
19 437 a need to extend the multimorbidity assessment to the remaining regions. Finally, this
20
21 438 research intentionally focused on the older population due to a significantly higher
22
23 439 burden of NCDs in this population group. Future research should use cohort data to
24
25 440 follow patients over a more extended time period to examine the impact of
26
27 441 multimorbidity and its effects in younger population groups in LMICs.²²
28
29
30
31
32
33
34

35 443 **Conclusion**

36
37 444 Multimorbidity poses substantial costs to individuals, households, health system, and
38
39 445 the wider society in Indonesia, which has an increasingly aging population.
40
41 446 Policymakers and employers in Indonesia should carefully design and invest in targeted
42
43 447 public health and workplace interventions at the individual and population level to avert
44
45 448 the adverse health and economic consequences of NCD multimorbidity.
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 450 **Declarations**

4
5 451 **Abbreviation**

6
7 452 CHE: Catastrophic health expenditure; HICs: High-income countries; IFLS: Indonesian Family Life
8
9 453 Survey; LMICs: Low-middle income countries; NCDs: Noncommunicable diseases; OOPE: Out-
10
11 454 of-pocket expenditure; PHC: Primary health care.

12
13 455 **Competing interests**

14
15 456 The authors have declared that no competing interests exist.

16
17 457 **Ethics approval**

18
19 458 The IFLS has been approved by ethics review boards at RAND Corporation and Gadjah Mada
20
21 459 University in Indonesia. Written informed consent was sought from all respondents prior to data
22
23 460 collection. As this study used IFLS publicly available datasets that contain no personal identification
24
25 461 of the respondents, no further ethical approval was sought.

26
27 462 **Author's contributions**

28
29 463 Author's contributions: The aim of the research was developed by TM, KA, JL. The methodology
30
31 464 development and analysis were conducted by TM, KA, HA, TP, JL. EH assisted in drafting the
32
33 465 discussion section and proofread all section. YZ, HJ, MI contributed to background and discussion
34
35 466 section. NN, BM, RA, JL provided critical input in revising the manuscript. All authors reviewed,
36
37 467 edited and commented on multiple versions of the manuscript.

38
39 468 **Availability of data and materials**

40
41 469 The datasets are publicly accessible after registration ([https://www.rand.org/well-being/social-and-](https://www.rand.org/well-being/social-and-behavioral-policy/data/FLS/IFLS/access.html)
42
43 470 [behavioral-policy/data/FLS/IFLS/access.html](https://www.rand.org/well-being/social-and-behavioral-policy/data/FLS/IFLS/access.html)).

44
45 471 **Acknowledgements**

46
47 472 The authors of the paper express sincere gratitude to the RAND for providing access to the data.
48
49 473 We acknowledge Nur Arna Sucianti from SurveyMeter, for guiding us with data merging.

50
51 474 **Funding**

52
53 475 This research received no specific grant from any funding agency in the public, commercial or not-
54
55 476 for-profit sectors.

477 **References**

- 478 1 World Health Organization. Noncommunicable diseases country profiles 2018.
479 World Health Organization, 2018 <https://apps.who.int/iris/handle/10665/274512>.
480 (accessed Oct 10, 2019).
- 481 2 Zhang L, Sun W, Wang Y, *et al*. Clinical Course and Mortality of Stroke Patients
482 With Coronavirus Disease 2019 in Wuhan, China. *Stroke* 2020; **51**: 2674–82.
- 483 3 United Nations, Department of Economic and Social Affairs, Population Division.
484 World Population Prospects 2019, Online Edition. Rev. 1. 2019. UN DESA, 2019
485 <https://population.un.org/wpp/Download/Standard/Population/> (accessed March 8,
486 2020).
- 487 4 Hussain MA, Huxley RR, Al Mamun A. Multimorbidity prevalence and pattern in
488 Indonesian adults: an exploratory study using national survey data. *BMJ open* 2015;
489 **5**: e009810.
- 490 5 Mboi N, Surbakti IM, Trihandini I, *et al*. On the road to universal health care in
491 Indonesia, 1990–2016: a systematic analysis for the Global Burden of Disease Study
492 2016. *The Lancet* 2018; **392**: 581–91.
- 493 6 United Nations. Political declaration of the third high-level meeting of the General
494 Assembly on the prevention and control of non-communicable diseases. United
495 Nations, 2018 https://www.un.org/en/ga/search/view_doc.asp?symbol=A/RES/73/2
496 (accessed March 8, 2020).
- 497 7 Sum G, Hone T, Atun R, *et al*. Multimorbidity and out-of-pocket expenditure on
498 medicines: a systematic review. *BMJ global health* 2018; **3**: e000505.
- 499 8 Wang L, Si L, Cocker F, Palmer AJ, Sanderson K. A systematic review of cost-of-
500 illness studies of multimorbidity. *Applied health economics and health policy* 2018;
501 **16**: 15–29.
- 502 9 Barnett K, Mercer SW, Norbury M, Watt G, Wyke S, Guthrie B. Epidemiology of
503 multimorbidity and implications for health care, research, and medical education: a
504 cross-sectional study. *The Lancet* 2012; **380**: 37–43.
- 505 10 Salisbury C. Multimorbidity: redesigning health care for people who use it. *The*
506 *Lancet* 2012; **380**: 7–9.
- 507 11 World Bank Group. Indonesia Health Financing System Assessment : Spend More,
508 Right and Better. Washington, DC: World Bank, 2016
509 <https://openknowledge.worldbank.org/handle/10986/25363> (accessed Sept 24,
510 2020).
- 511 12 Gani A, Budiharsana M. The consolidated report on Indonesia health sector review
512 2018. Jakarta, Indonesia: Bappenas, 2018.
- 513 13 Werdhani RA. Medical problem in Asia pacific and ways to solve it: The roles of
514 primary care/family physician (Indonesia Xperience). *J Family Med Prim Care*
515 2019; **8**: 1523–7.

- 1
2
3 516 14Rokx C. New insights into the provision of health services in Indonesia: A health
4 517 workforce study. World Bank Publications, 2010
5 518 <http://documents1.worldbank.org/curated/en/799111468038325818/pdf/538830PUB>
6 519 [0Heal101Official0Use0Only1.pdf](http://documents1.worldbank.org/curated/en/799111468038325818/pdf/538830PUB).
7
8
9 520 15Rajan VS, Patil A, Pambudi ES, Junedi B. Is Indonesia Ready to Serve? : An
10 521 analysis of Indonesia's primary health care supply-side readiness. Washington,
11 522 D.C. : World Bank Group: World Bank, 2018
12 523 <http://documents.worldbank.org/curated/en/484351538653658243/Is-Indonesia->
13 524 [Ready-to-Serve-An-Analysis-of-Indonesia-s-Primary-Health-Care-Supply-Side-](http://documents.worldbank.org/curated/en/484351538653658243/Is-Indonesia-)
14 525 [Readiness](http://documents.worldbank.org/curated/en/484351538653658243/Is-Indonesia-) (accessed March 20, 2019).
15
16 526 16Mahendradhata Y, Trisnantoro L, Dewi S, *et al*. The Republic of Indonesia Health
17 527 System Review. India: World Health Organization, 2017
18 528 <https://apps.who.int/iris/handle/10665/254716>.
19
20
21 529 17Alatas V, Banerjee A, Hanna R, Olken BA, Tobias J. Targeting the Poor: Evidence
22 530 from a Field Experiment in Indonesia. *American Economic Review* 2012; **102**:
23 531 1206–40.
24
25 532 18Noerdin E. Transport, health services and budget allocation to address maternal
26 533 mortality in rural Indonesia. *Transport and Communications Bulletin for Asia and*
27 534 *the Pacific* 2014; **84**: 1–14.
28
29 535 19Agustina R, Dartanto T, Sitompul R, *et al*. Universal health coverage in Indonesia:
30 536 concept, progress, and challenges. *The Lancet* 2018.
31
32 537 20BPJS Kesehatan. JKN coverage. 2020. <https://bpjs-kesehatan.go.id/bpjs/> (accessed
33 538 Oct 1, 2020).
34
35 539 21Jaspers L, Colpani V, Chaker L, *et al*. The global impact of non-communicable
36 540 diseases on households and impoverishment: a systematic review. *European Journal*
37 541 *of Epidemiology* 2015; **30**: 163–88.
38
39 542 22Lee JT, Hamid F, Pati S, Atun R, Millett C. Impact of noncommunicable disease
40 543 multimorbidity on healthcare utilisation and out-of-pocket expenditures in middle-
41 544 income countries: cross sectional analysis. *PLoS One* 2015; **10**: e0127199.
42
43 545 23Finkelstein EA, Chay J, Bajpai S. The economic burden of self-reported and
44 546 undiagnosed cardiovascular diseases and diabetes on Indonesian households. *PloS*
45 547 *one* 2014; **9**: e99572.
46
47 548 24Strauss J, Witoelar F, Sikoki B. The Fifth Wave of the Indonesia Family Life
48 549 Survey: Overview and Field Report: Volume 1. RAND Corporation, 2016
49 550 DOI:10.7249/WR1143.1.
50
51 551 25Strauss J, Witoelar F, Sikoki B, Wattie A. The fourth wave of the Indonesian
52 552 Family Life Survey (IFLS4): Overview and field report. RAND, 2009.
53
54 553 26Chobanian AV, Bakris GL, Black HR, *et al*. The seventh report of the joint
55 554 national committee on prevention, detection, evaluation, and treatment of high blood
56 555 pressure: the JNC 7 report. *Jama* 2003; **289**: 2560–71.
57
58
59
60

- 1
2
3 556 27 Grundy SM, Cleeman JI, Merz CNB, *et al.* Implications of recent clinical trials for
4 557 the national cholesterol education program adult treatment panel III guidelines.
5 558 *Journal of the American College of Cardiology* 2004; **44**: 720–32.
- 6
7
8 559 28 Hussain MA, Huxley RR, Al Mamun A. Multimorbidity prevalence and pattern in
9 560 Indonesian adults: an exploratory study using national survey data. *BMJ open* 2015;
10 561 **5**: e009810.
- 11
12 562 29 World Health Organization. The Asia-Pacific perspective: redefining obesity and
13 563 its treatment. 2000.
- 14
15 564 30 Xu K, Evans DB, Kawabata K, Zeramdini R, Klavus J, Murray CJ. Household
16 565 catastrophic health expenditure: a multicountry analysis. *The Lancet* 2003; **362**:
17 566 111–7.
- 18
19
20 567 31 Organisation for Economic Co-operation and Development (OECD). Purchasing
21 568 power parities (PPP). OECD, 2019 <https://data.oecd.org/conversion/purchasing536>
22 569 [power-parities-ppp.htm](https://data.oecd.org/conversion/purchasing536) (accessed Sept 10, 2019).
- 23
24 570 32 Vaezghasemi M, Ng N, Eriksson M, Subramanian S. Households, the omitted level
25 571 in contextual analysis: disentangling the relative influence of households and
26 572 districts on the variation of BMI about two decades in Indonesia. *International*
27 573 *journal for equity in health* 2016; **15**: 102.
- 28
29
30 574 33 Lee ES, Forthofer RN. Analyzing complex survey data. Sage, 2006.
- 31
32 575 34 Hosseinpoor AR, Bergen N, Kunst A, *et al.* Socioeconomic inequalities in risk
33 576 factors for non communicable diseases in low-income and middle-income countries:
34 577 results from the World Health Survey. *BMC public Health* 2012; **12**: 912.
- 35
36 578 35 Manne-Goehler J, Atun R, Stokes A, *et al.* Diabetes diagnosis and care in sub-
37 579 Saharan Africa: pooled analysis of individual data from 12 countries. *The lancet*
38 580 *Diabetes & endocrinology* 2016; **4**: 903–12.
- 39
40
41 581 36 Field AE, Coakley EH, Must A, *et al.* Impact of overweight on the risk of
42 582 developing common chronic diseases during a 10-year period. *Archives of internal*
43 583 *medicine* 2001; **161**: 1581–6.
- 44
45 584 37 Wang HH, Wang JJ, Wong SY, *et al.* Epidemiology of multimorbidity in China
46 585 and implications for the healthcare system: cross-sectional survey among 162,464
47 586 community household residents in southern China. *BMC medicine* 2014; **12**: 188.
- 48
49
50 587 38 Mondor L, Maxwell CJ, Hogan DB, *et al.* Multimorbidity and healthcare
51 588 utilization among home care clients with dementia in Ontario, Canada: a
52 589 retrospective analysis of a population-based cohort. *PLoS medicine* 2017; **14**:
53 590 e1002249.
- 54
55 591 39 Deonisia A. Kemenkes akan memperkuat fungsi preventif dan promotif melalui
56 592 akreditasi Puskesmas. Kompas.id. 2019; published online Oct 28.
57 593 <https://kompas.id/baca/utama/2019/10/28/kemenkes-akan-memperkuat-fungsi->
58 594 [preventif-dan-promotif-melalui-akreditasi-puskesmas/](https://kompas.id/baca/utama/2019/10/28/kemenkes-akan-memperkuat-fungsi-) (accessed Sept 10, 2020).
- 59
60

- 1
2
3 595 40Hoffmann T, Jansen J, Glasziou P. The importance and challenges of shared
4 596 decision making in older people with multimorbidity. *PLoS medicine* 2018; **15**:
5 597 e1002530.
- 6
7 598 41 World Health Organization. Preliminary results: Rapid assessment of service
8 599 delivery for NCDs during the COVID-19 pandemic. World Health Organization,
9 600 2020 [https://www.who.int/publications/m/item/rapid-assessment-of-service-](https://www.who.int/publications/m/item/rapid-assessment-of-service-delivery-for-ncds-during-the-covid-19-pandemic)
10 601 [delivery-for-ncds-during-the-covid-19-pandemic](https://www.who.int/publications/m/item/rapid-assessment-of-service-delivery-for-ncds-during-the-covid-19-pandemic) (accessed Sept 10, 2020).
- 11
12 602 42 World Health Organization. Multimorbidity: Technical Series on Safer Primary
13 603 Care. Geneva, 2016.
- 14
15 604 43 Kernick D, Chew-Graham CA, O’Flynn N. Clinical assessment and management
16 605 of multimorbidity: NICE guideline. *Br J Gen Pract* 2017; **67**: 235–6.
- 17
18 606 44 Chandraratne NK, Pathirathna K, Harrison C, Siriwardena AN. A comparison of
19 607 policies and guidelines related to multimorbidity in the UK, Australia and Sri Lanka.
20 608 *Australian journal of general practice* 2018; **47**: 15–9.
- 21
22 609 45 Wang X, Sun X, Birch S, *et al.* People-centred integrated care in urban China. *Bull*
23 610 *World Health Organ* 2018; **96**: 843–52.
- 24
25 611 46 Satibi S, Andayani TM, Endarti D, Suwantara IPT, Wintariani NP, Agustini NPD.
26 612 Comparison of Real Cost Versus the Indonesian Case Base Groups (INA-CBGs)
27 613 Tariff Rates Among Patients of High-Incidence Cancers Under the National Health
28 614 Insurance Scheme. *Asian Pacific journal of cancer prevention: APJCP* 2019; **20**:
29 615 117.
- 30
31 616 47 Schröders J, Wall S, Hakimi M, *et al.* How is Indonesia coping with its epidemic of
32 617 chronic noncommunicable diseases? A systematic review with meta-analysis. *PloS*
33 618 *one* 2017; **12**.
- 34
35 619 48 Vellakkal S, Subramanian S, Millett C, Basu S, Stuckler D, Ebrahim S.
36 620 Socioeconomic inequalities in non-communicable diseases prevalence in India:
37 621 disparities between self-reported diagnoses and standardized measures. *PloS one*
38 622 2013; **8**: e68219.
- 39
40 623 49 D’Hoore W, Bouckaert A, Tilquin C. Practical considerations on the use of the
41 624 Charlson comorbidity index with administrative data bases. *Journal of clinical*
42 625 *epidemiology* 1996; **49**: 1429–33.
- 43
44 626
- 45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

627 **Figure captions**628 **Figure 1. Prevalence of multimorbidity by age group and per capita household**
629 **expenditure**

630

631 ^{a)} respondents who reported that they had 2 or more chronic conditions related to noncommunicable
632 diseases (NCDs). ^{b)} Pooled sample of Wave 4 and Wave 5. Q1-Q5 refer to household expenditure
633 quintiles, where Q1 is the lowest and Q5 the highest household expenditure quintile.
634635 **Tables**636 **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

637 ^{a)} Values are unweighted counts and weighted percentages unless otherwise indicated638 ^{b)} We defined multimorbidity if the respondents reported that they had 2 or more chronic conditions related to
639 NCDs. Chronic diseases included: hypertension, diabetes, asthma, heart attack/coronary heart diseases, liver
640 disease, stroke, cancer, arthritis/rheumatism, hypercholesterolemia, and mental illness.641 ^{c)} Adjusted odds ratio (aOR) was estimated using multilevel logistic regression model of 2007 and 2014 IFLS
642 NCD: noncommunicable disease

637 **Table 2. Descriptive summary of health service use-financial burden and**
 638 **productivity outcomes by the number of NCDs (2014 IFLS)**
 639

	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				
<i>Outpatient services</i> ^{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
<i>Inpatient services</i> ^{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
<i>Catastrophic health expenditure (%; 95% CI)</i>				
>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% (0.6–2.5)	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				
<i>Labour participation (%; 95% CI)</i>				
50-60 years ^{d)}	84.3% (79.8–88.0)	74.3% (69.3–78.8)	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.

640

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)	9,400.36	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

642

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

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

646

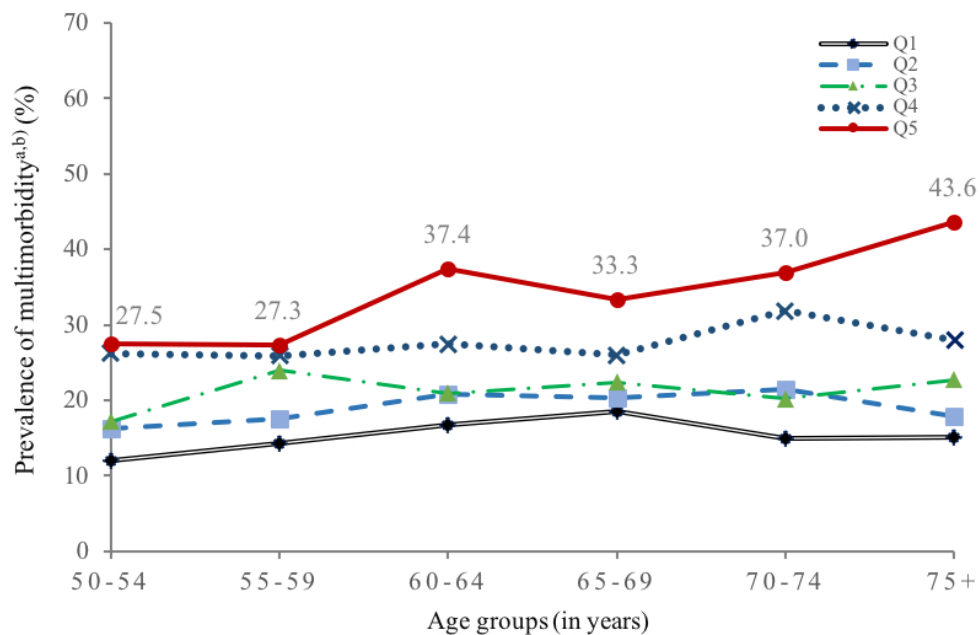


Figure 1. Prevalence of multimorbidity by age group and per capita household expenditure
 a) respondents who reported that they had 2 or more chronic conditions related to non-communicable
 diseases (NCDs). b) Pooled sample of Wave 4 and Wave 5. Q1-Q5 refer to household expenditure quintiles,
 where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

137x91mm (150 x 150 DPI)

SUPPLEMENTAL MATERIAL

Figure S1. Sample flowchart

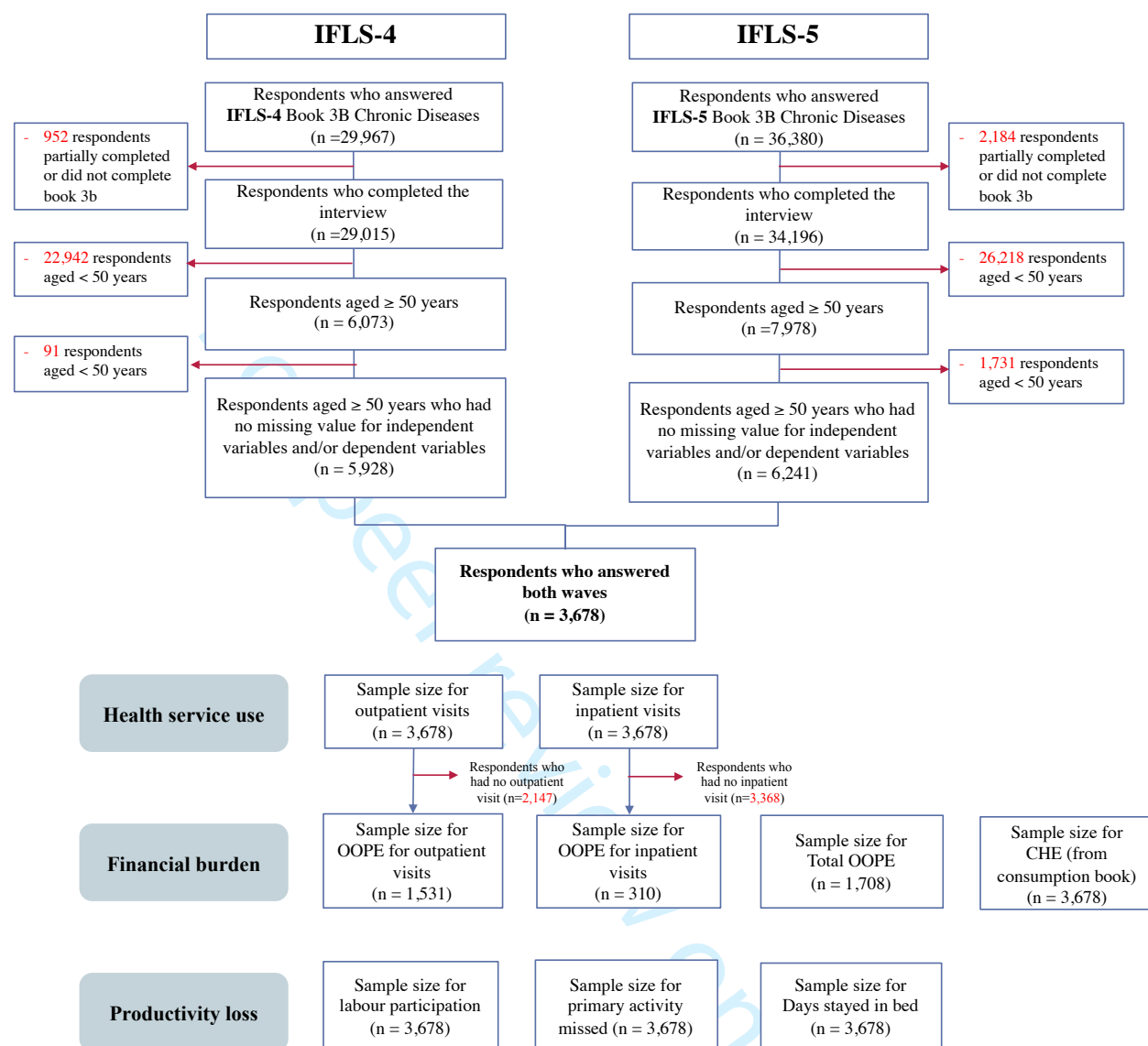


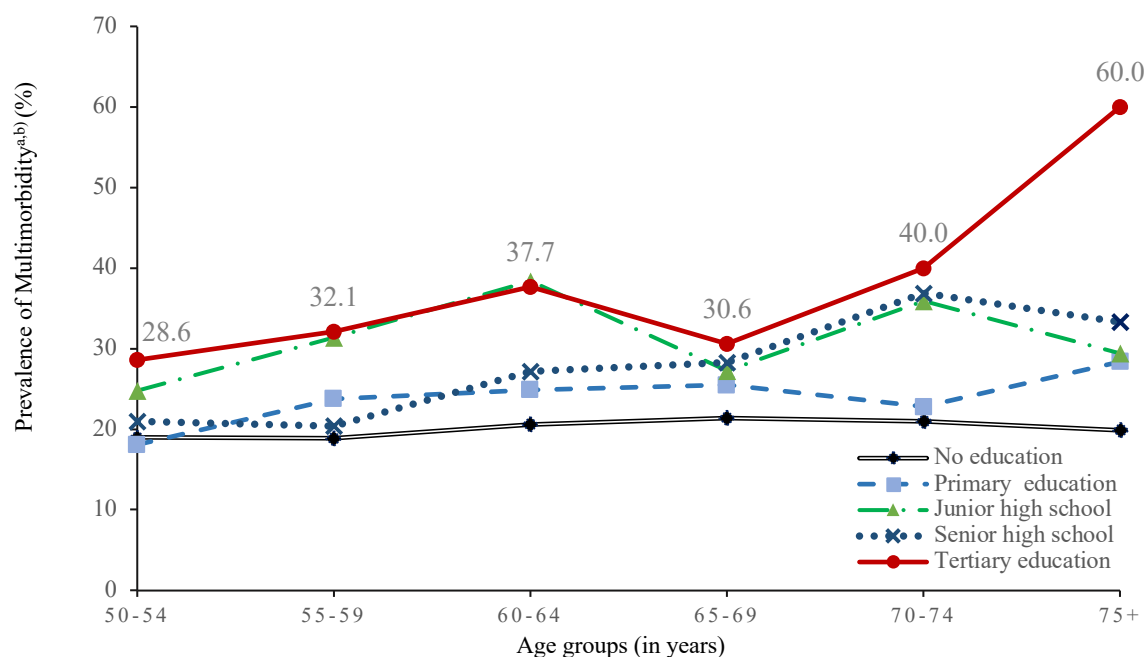
Table S1. List of variables for 2007 & 2014 IFLS analysis

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- <i>puskesmas</i> -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- <i>puskesmas</i> -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	

Variables	Type	Measurement	Source of measurement
Multimorbidity	Binary	5. 3+ NCDs	Book IIIB: CD06a – CD06r: Have a doctor/paramedic/nurse/ midwife ever told you that you had [list of chronic diseases]
		0. No	
		1. Yes (had 2 or more chronic conditions related to NCDs)	
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	Book IIIA: Age: How old are you?
		1. 50-59 years	
		2. 60-69 years	
		3. 70-79 years	
		4. 80+	
Sex	Binary	0. Male	Book IIIA: Sex: (identified by interviewers)
		1. Female	
Ethnicity	Categorical nominal	0. Javanese	
		1. Sundanese	
		2. Others	
Marital status	Binary	0. Unmarried/Divorce	Book IIIA HR00b: Are you currently married?
		1. Married or living together	
Education	Categorical ordinal	0. None	Book IIIA: DL06: What is the highest education level attended? DL07: What is the highest grade completed at school.
		1. Elementary school	
		2. Junior high school	
		3. High school	
		4. Tertiary	
Occupation	Categorical nominal	0. None	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?
		1. Casual worker	
		2. Self-employed	
		3. Government/private worker	
Health insurance status	Binary	0. Uninsured (Not covered by any insurance)	Book IIIB: AK01: Are you the policy holder/primary beneficiary of health benefits-health insurance?
		1. Insured	
Per capita expenditure	Categorical ordinal	0. Q1 (lowest)	Book KS
		1. Q2	
		2. Q3	
		3. Q4	
		4. Q5 (highest)	
Residency	Binary	0. Rural	Book T-2: SC06: (identified by interviewers)
		1. Urban	
Region	Categorical nominal	0. Java-Bali	Book T-2: SC01: province (identified by interviewers)
		1. Sumatra	
		2. Nusa Tenggara	
		3. Kalimantan	
		4. Sulawesi	

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 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)

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

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)	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 (4.0, 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 (5.2, 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

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 aOR (95% CI)	Number of visits IRR (95% CI)	Any visit aOR (95% CI)	Number of visits 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

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

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

Variables	Productivity loss		
	Labour participation aOR (95% CI)	Days primary activity missed IRR (95% CI)	Days stayed in bed 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		0.55*** (0.49–0.63)	0.33*** (0.26–0.42)
Government/private	n/a	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

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

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 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	1.12 (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

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

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 d/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) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up (b) <i>Case-control study</i> —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 (c) <i>Cross-sectional study</i> —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

	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) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —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

	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) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)		N/A
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time		N/A
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure		N/A
		<i>Cross-sectional study</i> —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				

	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.