LSE Middle East Centre

KUWAIT PROGRAMME

NONCOMMUNICABLE DISEASES AND RISK OF HOSPITALISATION IN KUWAIT

A GENERALISABLE APPROACH USING THE POPULATION-BASED WORLD HEALTH SURVEY

Abdullah Alibrahim

LSE Middle East Centre Kuwait Programme Paper Series | 15 | November 2022

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The Kuwait Programme is funded by the Kuwait Foundation for the Advancement of Sciences.

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Noncommunicable Diseases and Risk of Hospitalisation in Kuwait: A Generalisable Approach Using the Population-Based World Health Survey

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About the Authors

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Acknowledgments

We would like to thank Dr Zlako Nikoloski for his input on the project idea and analysis. We would also like to thank Dr Abdullah Al Ajeel from Kuwait's Ministry of Health for his time and effort in interpreting the data used in this analysis.

Abstract

Kuwait and countries in the Arabian Gulf region face an alarming prevalence of noncommunicable diseases (NCDs) that strains their health systems and threatens their economies, exacting far-reaching health and economic tolls. To that end, we estimated the increased risk of hospitalisation associated with diagnoses of most prevalent NCDs in Kuwait using a generalisable approach to establish cross-country disease burden comparisons and effective mitigation metrics. The study analysed responses from a nationally representative sample of 2,165 individuals that self-reported the number of hospitalisations in the last 12-months and NCD diagnoses from the World Health Survey (WHS) – Kuwait 2010. Hospitalisation rates were examined for individuals diagnosed with hypertension, diabetes mellitus, asthma, chronic lung condition, heart disease or angina, and stroke. Through group comparisons and statistical models, we found that hypertension, the most common NCD in Kuwait, was associated with a 75 percent increase in hospital admissions. In addition, heart disease was associated with a 495 percent increase in the risk of hospital admission after adjusting for potential confounders. Elevated hospitalisation risks associated with NCDs call for an urgent shift of resources to mitigate the subsequent morbidity, mortality, and burden on Kuwait's curative health services. We estimated the substantial burden on curative services associated with NCDs in Kuwait through a readily available, standardised approach to compare hospitalisation rates related to NCDs across over 70 countries that participated in the WHS.

Introduction

More than 40 million yearly deaths are attributable to noncommunicable diseases (NCDs), or over 70 percent of all mortality worldwide.[1] Due to the associated disability and mortality, NCDs are not only recognised as a health concern but as an economic threat to nations and healthcare systems. NCDs exact far-reaching health and economic tolls due to prolonged disability, premature deaths, reduced productivity, and increased demand for care.[2] The premature mortality associated with NCDs has been the subject of the United Nations Sustainable Development Goals (SDG), with a targeted reduction of NCD deaths by one-third.[3] Despite a notable decline in premature mortality from NCDs, the pace of change and disparities in improvements deem the SDG unattainable.[4] Kuwait and neighbouring countries in the Gulf Cooperation Council (GCC) face especially complex challenges in managing and mitigating the record-high prevalence of lifestyle-related NCDs.

The high prevalence of NCDs constitutes a growing strain on the healthcare system. In Kuwait, for example, more than one in four people has been diagnosed with hypertension, and nearly one in five with diabetes.[5] Additionally, the co-presence of the two most prevalent NCDs (diabetes and hypertension) is also very common in Kuwait and the region.[6]

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[1] 'World Health Statistics 2020 - Monitoring Health for the SDGs', *World Health Organization* (2020). Available at: https://apps.who.int/iris/bitstream/handle/10665/332070/9789240005105-eng.pdf (accessed 1 September 2021).

[2] J.M. Khalid et al., 'Rates and Risk of Hospitalisation Among Patients with Type 2 Diabetes: Retrospective Cohort Study Using the UK General Practice Research Database Linked to English Hospital Episode Statistics', *International Journal of Clinical Practice* 68/1 (2014), pp. 40–8; Samira H. Habib and Soma Saha, 'Burden of Non-communicable Disease: Global Overview', *Clinical Research and Reviews* 4/1 (2010), pp. 41–7. Available at: https://doi.org/10.1016/j.dsx.2008.04.005 (accessed 21 September 2021); Ghassan Shannan, 'Communicable Diseases in the Mediterranean Region', *eJIFCC* 29/3 (2018), pp. 164–70; Hanan Abdul Rahim, 'Non-communicable Diseases in the Arab World', *The Lancet* 383/9914 (2014), pp. 356–7. Available at: https://doi.org/10.1016/S0140-6736(13)62383-1 (accessed 21 September 2021).

[3] 'United Nations Sustainable Development', *United Nations*. Available at: https://sdgs.un.org/goals/goal3 (accessed 29 November 2020).

[4] James E. Bennett et al., 'NCD Countdown 2030: Pathways to Achieving Sustainable Development Goal target 3.4.' *The Lancet* 396/10255 (2020), pp. 918–34. Available at: https://doi.org/10.1016/S0140-6736(20)31761-X (accessed 21 September 2021).

[5] 'IDF Diabetes Atlas 9th edition', *International Diabetes Federation* (2019). Available at: https://www.diabetesatlas.org/upload/resources/material/20200302_133351_IDFATLAS9e-final-web.pdf (accessed 4 September 2021); Qais Al-Duwairi, 'Eastern Mediterranean Approach for Control of Non-Communicable Diseases Survey of Risk Factors for Chronic Non Communicable Diseases State of Kuwait', *Ministry of Health – Kuwait* (2015); Arshad M. Channanath et al., 'State of Diabetes, Hypertension, and Comorbidity in Kuwait: Showcasing the Trends as Seen in Native Versus Expatriate Populations', *Diabetes Care* 36/6 (2013), p. 2827. Available at: https://doi.org/10.2337/dc12-2451 (accessed 4 October 2022).

[6] S. W. Ng, Zaghloul et al., 'The Prevalence and Trends of Overweight, Obesity and Nutrition-related Non-communicable Diseases in the Arabian Gulf States', *Obesity Reviews* 12/1 (2011), pp. 1–13. Available at: https://doi.org/10.1111/j.1467-789X.2010.00750.x (accessed 14 September 2021); 'Noncommunicable Diseases (NCD) Country Profiles', *World Health Organization* (2018). Available at: https://apps.who.int/iris/handle/10665/274512 (accessed 14 September 2021).

This further complicates disease management and prevention and creates an impetus for overarching national strategies regionally, considering NCD-related mortality accounts for 69-83 percent of all deaths in the GCC.[7] As the relatively young population in the region ages, the burden is expected to increase in the following decades. The estimated burden of NCDs in the GCC is expected to reach US$68 billion by 2022 up from US$36 billion in 2013.[8]

Hospital admissions are one of the costliest elements of NCDs' financial burden. The hospitalisation risks associated with NCD can be considered a critical intermediate outcome towards estimating the economic burden and assessing the adequacy of primary care.[9] NCD-related hospitalisations can also be regarded as indicators of the effectiveness of disease management. Although isolated efforts examined the risk and cost of hospitalisations associated with the presence of individual NCDs in GCC countries, to the best of our knowledge, the association has not been examined for the interactive NCDs effects in Kuwait or the region.[10] This study fills this gap in research by estimating overnight hospital admission rates associated with NCD diagnoses from a comprehensive perspective while adjusting for comorbidities and demographic attributes. The methods proposed in this study can be generalised across multiple countries with similar health surveillance datasets.

Quantifying the risks of hospitalisations for NCDs is critical for crafting, optimising and evaluating the impact of national prevention, control and management strategies. Additionally, such quantitative examinations of hospitalisation rates can identify at-risk groups and guide resource allocation to achieve the highest reductions in hospitalisations and mortality. Developing tailored NCD prevention and management policies are imperative considering suboptimal disease management and control strategies for some NCDs in Kuwait and the GCC region.[11]

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[7] Ibid.

[8] 'GCC Economic Burden to Hit $68bn by 2022, if Governments Fail to Curb NCDs', *Arabian Gazette*. Available at: https://arabiangazette.com/gcc-economic-burden-hit-68bn-2022-ncds-20131203/ (accessed 29 November 2020).

[9] 'Better Noncommunicable Disease Outcomes: Challenges and Opportunities for Health Systems', *World Health Organization – Europe* (2014). Available at: https://www.euro.who.int/__data/assets/pdf_file/0005/247649/HSS-NCDs_Guide_WEB_Version_20-11.pdf (accessed 4 October 2022).

[10] Abdul Rahim, 'Non-communicable Diseases in the Arab world'; Khalid Al-Rubeaan, 'The Impact of Diabetes Mellitus on Health and Economy of Gulf Cooperation Council Countries', *Diabetes Management* 4/4 (2014), pp. 381–90. Available at: https://www.proquest.com/openview/afaeafda6e13bd707cd161808ad214cb/1?pq-origsite=gscholar&cbl=636389 (accessed 4 October 2022); Hanan Badr et al., 'Review of Non-communicable Disease Research Activity in Kuwait: Where is the Evidence for the Best Practice?' *Annals of Global Health* 85/1 (2019), p. 45.

[11] Layla Alhyas et al., 'Quality of Type 2 Diabetes Management in the States of the Co-operation Council for the Arab States of the Gulf: A Systematic Review', *PLoS ONE* 6/8 (2011).

Fortunately, evidence strongly supports the benefits of NCD-focused strategic investments and efforts to reduce disease burdens.[12] Investments that target modifiable NCD risk factors and active disease management may reduce disease incidence, improve quality of life, and reduce the need for hospitalisations. The efficacy of such investments can be hard to gauge when the disease burdens and risks are ambiguous due to underdeveloped health information technology systems and shortage in surveillance studies.[13] The dearth of administrative and surveillance health data requires alternative approaches including secondary data analyses of existing health data. Towards that goal, we analysed the readily available and standardised World Health Survey (WHS) data in Kuwait to answer critical questions related to the risk of hospital admissions associated with the most prevalent NCDs.

This study aims to quantify the risk of hospitalisation associated with NCDs in Kuwait using existing National Health Surveillance survey data. The study relies on self-reported NCD diagnoses and one-year hospitalisations reported by respondents in the 2010 WHS–Kuwait. The WHS–Kuwait is a nationally representative survey of the adult population conducted between 2008 and 2010.[14] The WHS is the only nationally representative data source in Kuwait to date and many countries in the region that captures health utilisation data and individual characteristics. Therefore, this study offers a unique and inclusive assessment of hospitalisation risks associated with NCDs in Kuwait and an opportunity to compare NCD hospitalisation risks across over 70 countries participating in the WHS.[15]

Material and Methods

Study Design and Data

The study is a cross-sectional, retrospective individual-level analysis of self-reported hospital admissions and disease presence. The study utilises WHS–Kuwait data, a national, cross-sectional survey of Kuwaitis and Non-Kuwaitis living in Kuwait.[16] It is developed by the World Health Organization (WHO) as a comprehensive and standardised perspective on the health of the populations that can be adapted across different settings and cultures. To date, the WHS–Kuwait remains the only national health surveillance survey

[12] Richard Horton and Selina Lo, 'Investing in Health: Why, What, and Three Reflections', *The Lancet* 382/9908 (2013), pp. 1859–61; Rachel Nugent et al., 'Investing in Non-communicable Disease Prevention and Management to Advance the Sustainable Development Goals', *The Lancet* 391/10134 (2018), pp. 2029–35. Available at: https://doi.org/10.1016/S0140-6736(18)30667-6 (accessed 4 October 2022).

[13] Abdul Rahim et al., 'Non-communicable Diseases in the Arab World'; Badr et al., 'Review of Non-communicable Disease Research Activity in Kuwait: Where is the Evidence for the Best Practice?'; Al-Rubeaan, 'The Impact of Diabetes Mellitus on Health and Economy of Gulf Cooperation Council Countries.'

[14] 'World Health Survey in Kuwait Summary Report', *Ministry of Health – Kuwait* (2013). Available at:https://www.moh.gov.kw/Renderers/ShowPdf.ashx?Id=8d14b250-ee29-4220-862e-a5f0e00056de (accessed 12 January 2019).

[15] 'World Health Survey', *World Health Organization*. Available at: https://www.who.int/healthinfo/survey/countries/en/ (accessed 29 March 2021).

[16] 'World Health Survey in Kuwait Summary Report', *Ministry of Health – Kuwait*.

that studies both Kuwaiti and Non-Kuwait residents in the country. Therefore, the WHS data is best suited for analyses on all segments of the population in Kuwait, including the expatriate population, which comprises 70 percent of Kuwait's total population. The survey covers all six governorates in Kuwait based on a simple randomisation technique, where respondents are randomly selected within each governorate for a balanced representation. Unlike administrative hospital data that provide episode-level perspectives, WHS data offers individual-level data with detailed attributes for unique insights given the limited availability of administrative hospital data in Kuwait.

Measures and Variables

Variable selection from the WHS was guided by the Andersen healthcare utilisation model to quantify the association between NCDs and increased risk of hospital admissions.[17] The Andersen model is a commonly used framework that conceptualises the factors that lead to healthcare utilisation according to three mechanisms. Specifically, we classify relevant variables in the WHS according to the mechanisms from the model that contribute to the utilisation of healthcare: predisposing factors (such as demographics and smoking behaviour), enabling factors (access and organisation), and needs (chronic health problems). The analysis measures the link between NCDs (as health needs) and hospitalisations (utilisation) while adjusting for predisposing and enabling factors. Therefore, we include each subjects' demographic and socioeconomic attributes as predisposing and enabling aspects of an individual's health utilisation. Table 1 below shows all survey questions and variables.

[17] Ronald Andersen and John F. Newman, 'Societal and Individual Determinants of Medical Care Utilisation in the United States', *The Milbank Memorial Fund Quarterly. Health and Society* 51/1 (1973), p. 95. Available at: https://doi.org/10.2307/3349613 (accessed 4 October 2022); Lu Ann Aday and Ronald Andersen, 'A Framework for the Study of Access to Medical Care', *Health Services Research* 9/3 (1974), pp. 208–20.

Table 1: Study Variables and Survey Questions from the World Health Survey

Study Variable	Survey Questions	Questions
Number of hospital admissions	• Over the last 12 months, how many different times were you a patient in a hospital for at least one night?	Q5006
Gender	• Record sex of the respondent	Q1009
Age	• How old are you now?	Q1011
Smoking behavior	• Have you ever smoked tobacco or used smokeless tobacco? • Do you currently use (smoke, sniff or chew) any tobacco products such as cigarettes, cigars, pipes, chewing tobacco, shisha or snuff?	Q3001 Q3002
Active lifestyle	• Does your work involve vigorous/moderate-intensity activity that causes large increases in breathing or heart rate, [example army+ oil field] for at least 10 minutes continuously? • Do you do any vigorous/moderate intensity sports, fitness or recreational (leisure) activities that cause large increases in breathing or heart rate [like running or football], for at least 10 minutes continuously?	Q3016, Q3019 Q3025, Q3028
Education	• What is the highest level of education that you have completed?	Q1016
Employment status	• Who is/was your employer in your current/most recent MAIN job? • What is the main reason you are not currently working?	Q1509 Q1504
Nationality	• What is your nationality?	Q1018
Obesity	• Measured height in centimeters • Measured weight in kilograms	Q2506 Q2507
Hypertension	• Have you ever been diagnosed with hypertension?	Q4060
Diabetes	• Have you ever been diagnosed with diabetes (high blood sugar)?	Q4022
Asthma	• Have you ever been diagnosed with asthma (an allergic respiratory disease)?	Q4033
Chronic lung disease	• Have you ever been diagnosed with chronic lung disease (emphysema, bronchitis, COPD)?	Q4025
Heart disease or angina	• Have you ever been diagnosed with angina or angina pectoris (a heart disease) (chest pain)?	Q4014
Stroke	• Have you ever been told by a health professional that you have had a stroke?	Q4010

List and classification of survey questions and corresponding study variables.

The primary outcome variable in this study is the number of hospital admissions over the last 12 months. Specifically, the respondents were asked to enter a number answer 'Over the last 12 months, how many different times were you a patient in a hospital for at least one night?' Respondents were asked to specify the reason for each admission. Admissions that were due to maternal care were excluded, while all other reasons for admissions were included.

The key independent variables in this study are the individual's NCDs. We included all NCDs collected in the WHS survey: hypertension, diabetes, asthma, chronic lung disease, heart disease or angina, and stroke. The respondent's answer to 'Have you ever been diagnosed with [condition]?' was coded as a binary variable based on the respondent's answer (no = 0, yes = 1). Other measures of chronic conditions in the survey, such as actual blood glucose measurement or blood pressure, were considered. Still, low response rates drastically limit the sample size and power of the conclusions. Therefore, only self-reported measures of chronic conditions were studied.

Several demographic and behavioural variables were considered: age, gender, educational level, employment status, socioeconomic status (SES), nationality, smoking behaviour, and physical activity. All demographic variables are categorical variables except age, which was discretised into age groups from the continuous age variable. Individuals were assigned a wealth score using factor analysis based on responses to wealth-related questions from the household survey, such as property and asset ownership (cars, television, etc.). Individuals were then divided into five quintiles based on their wealth score [1 = poorest, 5 = richest]. The variables and approach used to arrive at the wealth quintiles are outlined in the World Food Programme guidance paper.[18] Subjects' nationalities were grouped as Kuwaiti or Non-Kuwaiti. It is worth mentioning that Kuwait offers universal health coverage for nationals and expatriates, but expatriates have higher copays. Therefore, financial, language, and waiting time barriers may influence access. The non-Kuwaiti and SES variables represent the enabling factors from the Andersen model to capture obstacles to care. The education variable considered four educational degree levels: primary school or less, secondary school, high school, college, or higher degree. Four employment categories were considered; never worked, works in the private sector, public sector, and retired.

Statistical Analyses

We first produced summary statistics for the study sample and subsets of respondents with the three most prevalent NCDs and obesity. The difference in hospitalisation rates was examined through group comparisons between individuals with and without NCDs and inspected for statistically significant differences. The difference in hospitalisation rates by NCD status was also inspected at the covariate level (age group, gender, education, smoking behaviour, wealth, physical activity, nationality, employment status, and comorbidities). Differences in hospitalisation rates between individuals with NCDs and without NCDs were compared using t-tests to determine the statistical significance of the difference.

[18] 'Creation of a Wealth Index – VAM Guidance Paper', *World Food Programme* (2017). Available at: https://docs.wfp.org/api/documents/WFP-0000022418/download/ (accessed 14 November 2022).

The second phase of the statistical analysis includes explorative generalised linear multivariate models that regress the count of hospitalisations on the NCD conditions and all covariates in the study to isolate the influence of diabetes. This approach measures NCDs' influence and adjusts for the effects of confounders such as age, gender, education, employment, and SES. Since the number of hospitalisations was a count variable, Poisson and negative binomial regressions are fit to measure the association between study covariates and the number of hospitalisations. Multivariate linear regression was also used as a validation mechanism.

The group analysis also guided potential interactions between key study independent variables (NCDs) and confounders such as age, gender, wealth score, nationality, etc. These interactions were examined iteratively by fitting models with interaction terms and noting the statistical significance of the new terms and changes to the model's fit measures using the chi-squared test of significance.

The approach offers a comprehensive take on quantifying the effects of individual NCDs on hospitalisation rates, then stratified the risk associated with each chronic condition by examining the changes in hospitalisation rates associated with a diagnosis for subgroups of the sample. After, multivariate regression adjusted for the potential confounding by examining the isolated and interactive effects of each NCD. The study employed a pairwise deletion approach for missing data to maximise the sample size. The same analyses were also run using listwise deletion to verify the robustness of findings and randomness of missing data.

Results

A total of 2,165 responses from the WHS–Kuwait individual survey reported the number of overnight hospital admissions over the last 12 months (out of 3,826 responses). The subsample of respondents that did provide the number of admissions is referred to as the study sample hereafter. The average number of reported hospitalisations in the last 12 months was 0.206 overnight hospital admission per individual with a variance of 0.726 (Figure 1). The majority of the respondents reported no inpatient hospital admissions during the previous 12 months (1,921 out of 2,165, 88.7%). Figure 1 shows the distribution of the reported hospitalisations by 2,165 respondents. The most common NCDs were hypertension (16.1%), diabetes (15.0%), and asthma (13.5%). Additionally, 4.1% reported being diagnosed with a chronic lung condition, 3.6% with heart disease or angina, and 0.8% with stroke. All 3 of the most prevalent NCDs and obesity were associated with age, nationality, highest educational degree, and employment (Pearson Chi-squared Test of association, p-values < 0.01). Approximately 34% of the respondents had at least one NCD, and 14% had two or more NCDs. Figure 2 shows an intersection plot capturing the frequency conditions and combinations of comorbidities in the study sample.

Figure 1: Distribution of Overnight Hospital Admissions for the World Health Survey – Kuwait Respondents.

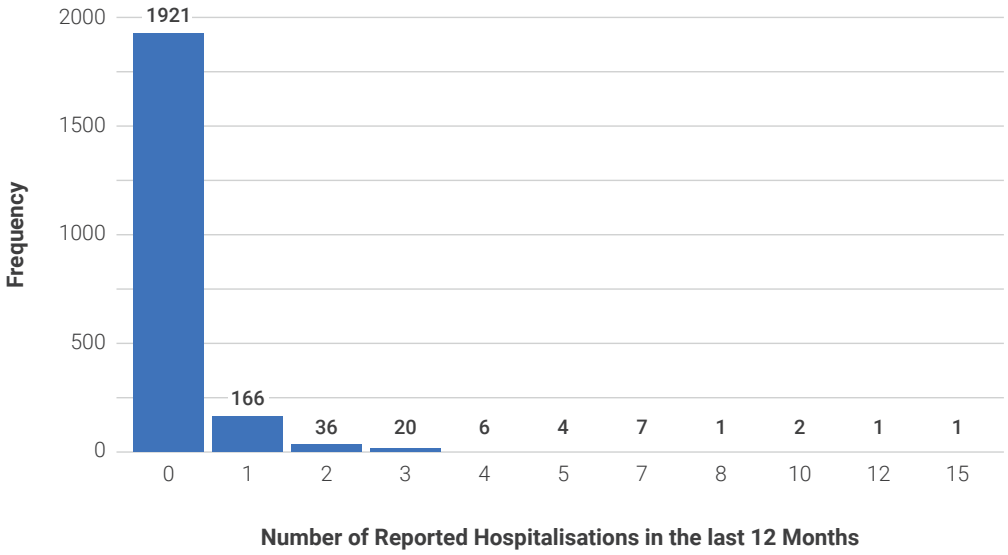
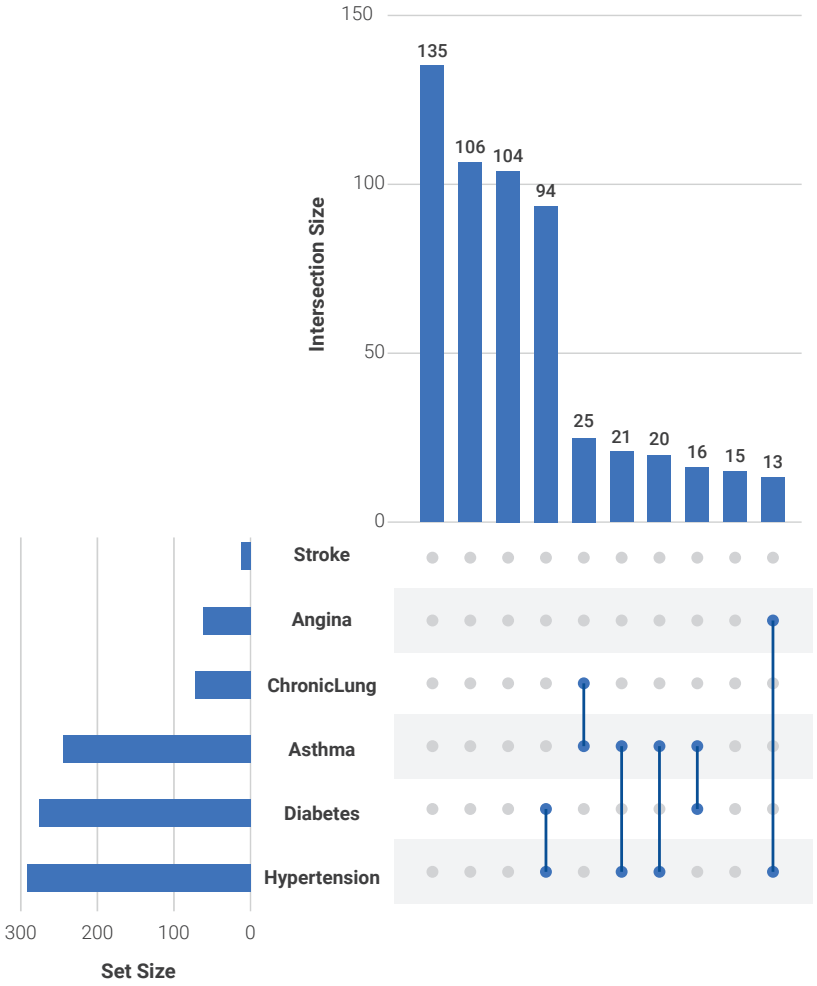


Figure 2: Frequency of Conditions and Multiple Comorbidities as Occurring in the Study Sample



A substantial proportion of the respondents were found to be obese (39.9%). Summary statistics were calculated for the whole sample and based on the three most prevalent NCD diagnoses, obesity and no NCDs (Table 1). Patients with hypertension reported 175% higher hospital admission rates than individuals with no hypertension; 0.44 overnight hospital admissions per person per year (pppy) with hypertension compared to 0.16 overnight hospital admissions pppy without hypertension (p-value < 0.001). Individuals with diabetes reported a 94% higher inpatient hospitalisation rate, 0.35 overnight hospital admissions per year for individuals with diabetes vs. 0.21 overnight hospital admissions per year for individuals with no diabetes (p-value = 0.0074). Asthma diagnoses were associated with 68% higher overnight hospital admission rates; 0.32 overnight hospital admissions per year for individuals diagnosed with asthma compared to 0.19 overnight hospital admissions per year for individuals not diagnosed with asthma (p-value = 0.029). The absolute difference in hospitalisation rates by NCD status may be confounded because individuals with NCDs tend to be older, less educated, retired, and are more likely to have comorbidities, as we see in the summary statistics for each NCD.

Table 2: Count and Percentages of Most Prevalent Noncommunicable Diseases in the Study Sample and Sub-samples.

	Full Sample (n = 2,165)		Obese (n = 764)		Hypertension (n = 346)		Diabetes (n = 324)		Asthma (n = 291)		No NCD (n = 1,428)	
Utilisation												
Hospitalisations in last 12 months												
Average	0.21	0.17, 0.24	0.22	0.16, 0.28	0.44	0.31, 0.57	0.35	0.23, 0.46	0.32	0.21, 0.44	0.15	0.11, 0.19
0	1,921	88.73%	663	34.51%	273	14.21%	267	13.90%	243	12.65%	1,309	68.14%
1	166	7.67%	74	44.58%	42	25.30%	34	20.48%	30	18.07%	88	53.01%
2	36	1.66%	13	36.11%	15	41.67%	13	36.11%	6	16.67%	14	38.89%
3+	42	1.94%	14	33.33%	16	38.10%	10	23.81%	12	28.57%	17	40.48%
Predisposing Factors												
Gender												
Female	1,297	59.90%	488	37.63%	213	16.42%	198	15.27%	200	15.42%	847	65.30%
Male	868	40.10%	276	31.80%	133	15.32%	126	14.52%	91	10.48%	581	66.94%
Age												
Average	40.1	39.51, 40.68	43	42.09, 43.95	53	51.50, 54.45	53.6	52.11, 55.13	42.4	40.60, 44.16	36.31	35.70, 36.91
< 29	558	25.80%	118	21.15%	15	2.69%	18	3.23%	64	11.47%	465	83.33%
30–39	625	28.90%	211	33.76%	43	6.88%	30	4.80%	85	13.60%	480	76.80%
40–49	453	20.90%	197	43.49%	73	16.11%	67	14.79%	50	11.04%	290	64.02%
50–59	293	13.50%	145	49.49%	103	35.15%	95	32.42%	44	15.02%	127	43.34%
60–69	161	7.40%	72	44.72%	66	40.99%	71	44.10%	28	17.39%	52	32.30%
70+	75	3.50%	21	28.00%	46	61.33%	43	57.33%	20	26.67%	14	18.67%

Smoking status (n = 2,149)												
Never smoked	1,750	81.43%	59	3.37%	43	2.46%	22	1.26%	91	5.20%	1159	66.23%
Past smoker	61	2.84%	22	36.07%	15	24.59%	18	29.51%	6	9.84%	33	54.10%
Current smoker	388	18.05%	107	27.58%	43	11.08%	52	13.40%	44	11.34%	225	57.99%
Physical activity (n = 2,138)												
Some moderate or vigorous activity	807	37.7%	287	35.56%	85	10.53%	64	7.93%	116	14.37%	569	70.51%
No physical activity	1,331	62.3%	470	35.31%	254	19.08%	252	18.93%	169	12.70%	847	63.64%
Education (n = 2,042)												
Primary school or less	162	7.93%	70	43.21%	52	32.10%	56	34.57%	28	17.28%	74	45.68%
Secondary school	351	17.19%	135	38.46%	59	16.81%	54	15.38%	55	15.67%	222	63.25%
High school	690	33.79%	241	34.93%	89	12.90%	81	11.74%	98	14.20%	462	66.96%
College or more	839	41.09%	260	30.99%	92	10.97%	72	8.58%	80	9.54%	633	75.45%
Employment status (n = 2,159)												
Never worked	795	36.90%	313	39.37%	153	19.25%	148	18.62%	126	15.85%	494	62.14%
Public sector	797	37.00%	257	32.25%	88	11.04%	67	8.41%	104	13.05%	571	71.64%
Private sector	315	14.6%	98	31.11%	29	9.21%	37	11.75%	22	6.98%	238	75.56%
Retired	249	11.50%	92	36.95%	73	29.32%	70	28.11%	38	15.26%	120	48.19%

Table 2 (continued)

	Full Sample (n = 2,165)		Obese (n = 764)		Hypertension (n = 346)		Diabetes (n = 324)		Asthma (n = 291)		No NCD (n = 1,428)	
Enabling Factors												
Nationality (n = 2,161)												
Kuwaiti	1,548	71.60%	557	35.98%	271	17.51%	260	16.80%	248	16.02%	964	62.27%
Wealth score (5 is highest; n = 2,042)												
5	422	20.70%	161	38.15%	71	16.82%	67	15.88%	61	14.45%	275	65.17%
4	425	20.80%	155	36.47%	71	16.71%	51	12.00%	47	11.06%	283	66.59%
3	416	20.40%	132	31.73%	61	14.66%	65	15.63%	59	14.18%	277	66.59%
2	399	19.50%	134	33.58%	49	12.28%	47	11.78%	53	13.28%	273	68.42%
1	380	18.60%	148	38.95%	65	17.11%	69	18.16%	54	14.21%	243	63.95%
Need Factors												
Comorbidities												
Obese	764	39.90%	764	100.00%	181	23.69%	161	21.07%	126	16.49%	430	56.28%
Hypertension	346	16.10%	181	52.31%	346	100.00%	175	50.58%	81	23.41%		
Diabetes	324	15.00%	161	50.00%	175	54.01%	324	100.00%	66	20.37%		
Asthma	291	13.50%	126	43.30%	81	27.84%	66	22.68%	291	100.00%		
Chronic lung condition	88	4.10%	38	37.50%	33	37.50%	26	29.55%	57	64.77%		
Heart disease or angina	77	3.60%	26	33.77%	41	53.25%	33	42.86%	21	27.27%		
Stroke	18	0.80%	4	22.22%	10	55.56%	8	44.44%	4	22.22%		
Two or more NCDs	300	14.00%	150	50.00%	230	76.67%	205	68.33%	138	46.00%		

For the full sample, the percentage represents the proportion compared to those who responded to this category. For each NCD, the percentage represents the proportion of each row subgroup that reported the column NCD. For numerical variables (hospital admission and age), means and 95% confidence intervals are reported.

To explore the significance of the association between NCDs and risk of hospitalisations, hospitalisation rates were examined across subgroups of the sample. Table 3 shows that there were several subgroups in which NCDs were associated with higher hospitalisation rates. Specifically, older adults, lower SES, retirees, currently smoking, and non-exercising respondents reported significantly higher hospitalisation rates associated with NCDs than similar individuals who did not report any NCDs. In most cases, individuals in the previously mentioned subgroups reported hospitalisations that were at least 2-fold over the same subgroup with no NCDs with significant p-values. The full results of the differences in hospitalisation rates for different NCDs across the sample and subgroups can be found in Table 3. The findings confirmed an overall increase in the risk of hospitalisation associated with NCDs for the full sample and several subgroups based on the variables studied.

Table 3: Hospitalisation Rates per 12 Months per Person Across Study Subgroups and Covariates

	Full Sample (n = 2,165)	Obese (n = 764)	Hypertension (n = 346)	Diabetes (n = 324)	Asthma (n = 291)	No NCD (n = 1,428)
Hospitalisation rate	0.21 (0.17, 0.24)	0.22 (0.16, 0.28)	0.44* (0.31, 0.57)	0.35* (0.23, 0.46)	0.32* (0.21, 0.44)	0.15 (0.11, 0.19)
Predisposing Factors						
Gender						
Female	0.22 (0.17, 0.27)	0.20 (0.15, 0.26)	0.41* (0.25, 0.57)	0.40* (0.24, 0.57)	0.34 (0.19, 0.49)	0.16 (0.10, 0.22)
Male	0.19 (0.14, 0.24)	0.25 (0.13, 0.36)	0.50* (0.28, 0.71)	0.26 (0.12, 0.40)	0.29 (0.13, 0.44)	0.12 (0.08, 0.17)
Age group						
< 29	0.18 (0.11, 0.25)	0.21 (0.11, 0.32)	0.47 (0.00, 0.93)	0.78 (0.15, 1.40)	0.33 (0.15, 0.50)	0.14 (0.07, 0.22)
30–39	0.14 (0.10, 0.19)	0.15 (0.09, 0.21)	0.30* (0.15, 0.46)	0.13 (0.00, 0.29)	0.18 (0.03, 0.32)	0.12 (0.08, 0.17)
40–49	0.23 (0.15, 0.32)	0.23 (0.12, 0.35)	0.55* (0.22, 0.87)	0.40 (0.09, 0.72)	0.12 (0.00, 0.28)	0.17 (0.07, 0.26)
50–59	0.23 (0.12, 0.35)	0.27 (0.09, 0.44)	0.25 (0.09, 0.41)	0.22 (0.12, 0.32)	0.27 (0.11, 0.43)	0.27 (0.04, 0.49)
60–69	0.30 (0.15, 0.46)	0.15 (0.00, 0.30)	0.61* (0.25, 0.96)	0.34* (0.10, 0.58)	0.68* (0.10, 1.26)	0.02 (0.00, 0.06)
70+	0.45 (0.15, 0.75)	0.71 (0.00, 1.49)	0.59 (0.12, 1.05)	0.53 (0.05, 1.02)	1.05 (0.03, 2.07)	0.07 (0.00, 0.21)
Smoking status						
Never smoked	0.21 (0.16, 0.25)	0.21 (0.15, 0.27)	0.43* (0.28, 0.57)	0.35* (0.21, 0.49)	0.32 (0.18, 0.45)	0.16 (0.11, 0.21)
Past smoker	0.15 (0.00, 0.29)	0.27 (0.0, 0.57)	0.13 (0.00, 0.31)	0.11 (0.00, 0.26)	0.67 (0.00, 1.64)	0.09 (0.00, 0.27)
Current smoker	0.22* (0.15, 0.29)	0.27 (0.11, 0.43)	0.63* (0.30, 0.96)	0.38* (0.16, 0.61)	0.32 (0.12, 0.52)	0.10 (0.05, 0.15)
Physical activity						
Some moderate or vigorous activity	0.20 (0.13, 0.27)	0.23 (0.13, 0.34)	0.39 (0.14, 0.63)	0.39 (0.07, 0.72)	0.24 (0.09, 0.39)	0.17 (0.09, 0.25)
No physical activity	0.21 (0.17, 0.25)	0.21 (0.15, 0.28)	0.46* (0.31, 0.62)	0.34* (0.22, 0.46)	0.38* (0.22, 0.55)	0.13 (0.09, 0.17)
Highest education degree						
Primary school or less	0.17 (0.06, 0.28)	0.11 (0.04, 0.19)	0.25 (0.00, 0.53)	0.27 (0.01, 0.53)	0.54 (0.00, 1.07)	0.12 (0.00, 0.24)
Secondary school	0.23 (0.16, 0.30)	0.24 (0.12, 0.37)	0.37 (0.19, 0.56)	0.33 (0.12, 0.55)	0.36 (0.16, 0.56)	0.14 (0.07, 0.20)
High school	0.18 (0.13, 0.23)	0.22 (0.14, 0.30)	0.43* (0.19, 0.66)	0.31 (0.11, 0.51)	0.24 (0.09, 0.40)	0.13 (0.08, 0.17)
College or higher	0.18 (0.11, 0.24)	0.21 (0.10, 0.33)	0.50* (0.22, 0.78)	0.31 (0.07, 0.54)	0.07 (0.02, 0.13)	0.15 (0.07, 0.22)

Employment status						
Never worked	0.24 (0.18, 0.30)	0.23 (0.14, 0.31)	0.39* (0.21, 0.58)	0.41* (0.22, 0.61)	0.46* (0.23, 0.69)	0.16 (0.10, 0.22)
Public sector	0.19 (0.12, 0.25)	0.18 (0.10, 0.25)	0.41 (0.16, 0.66)	0.24 (0.01, 0.46)	0.16 (0.05, 0.27)	0.17 (0.09, 0.25)
Private sector	0.14 (0.05, 0.23)	0.23 (0.00, 0.48)	0.48 (0.00, 0.98)	0.24 (0.00, 0.49)	0.14 (0.00, 0.28)	0.09 (0.00, 0.18)
Retired	0.25 (0.15, 0.35)	0.30 (0.14, 0.47)	0.58* (0.28, 0.87)	0.37* (0.14, 0.60)	0.42* (0.17, 0.67)	0.09 (0.03, 0.15)
Enabling Factors						
Nationality						
Kuwaiti	0.23 (0.18, 0.27)	0.23 (0.17, 0.30)	0.42* (0.28, 0.55)	0.37* (0.24, 0.50)	0.32* (0.20, 0.44)	0.16 (0.11, 0.22)
Non-Kuwaiti	0.16 (0.10, 0.22)	0.18 (0.06, 0.31)	0.53* (0.21, 0.86)	0.27 (0.03, 0.51)	0.35 (0.00, 0.71)	0.11 (0.05, 0.16)
Wealth score (5 is highest)						
5	0.15 (0.10, 0.20)	0.16 (0.05, 0.26)	0.28 (0.05, 0.51)	0.31 (0.06, 0.57)	0.20 (0.05, 0.35)	0.09 (0.06, 0.13)
4	0.22 (0.12, 0.31)	0.17 (0.06, 0.29)	0.49 (0.19, 0.79)	0.20 (0.05, 0.34)	0.17 (-0.01, 0.35)	0.16 (0.05, 0.27)
3	0.28 (0.18, 0.39)	0.37 (0.16, 0.58)	0.67 (0.24, 1.10)	0.49 (0.11, 0.88)	0.58 (0.19, 0.96)	0.23 (0.10, 0.36)
2	0.13 (0.07, 0.19)	0.17 (0.08, 0.27)	0.27 (0.11, 0.42)	0.21 (0.06, 0.37)	0.17 (0.03, 0.31)	0.10 (0.03, 0.17)
1	0.25 (0.17, 0.33)	0.28 (0.15, 0.41)	0.63* (0.31, 0.95)	0.55* (0.27, 0.83)	0.54* (0.19, 0.89)	0.12 (0.07, 0.17)
Need Factors						
Comorbidities						
Obese	0.22 (0.16, 0.28)	0.22 (0.16, 0.28)	0.39 (0.22, 0.55)	0.25 (0.11, 0.40)	0.32 (0.15, 0.48)	
Hypertension	0.44 (0.31, 0.57)	0.39 (0.22, 0.55)	0.44 (0.31, 0.57)	0.50 (0.30, 0.69)	0.72 (0.37, 1.06)	
Diabetes	0.35 (0.23, 0.46)	0.25 (0.11, 0.40)	0.50 (0.30, 0.69)	0.35 (0.23, 0.46)	0.70 (0.30, 1.09)	
Asthma	0.32 (0.21, 0.44)	0.32 (0.15, 0.48)	0.72 (0.37, 1.06)	0.70 (0.30, 1.09)	0.32 (0.21, 0.44)	
Chronic lung condition	0.56 (0.26, 0.85)	0.71 (0.11, 1.31)	1.15 (0.45, 1.85)	0.85 (0.18, 1.51)	0.51 (0.17, 0.85)	
Heart disease or angina	1.19 (0.73, 1.66)	1.69 (0.70, 2.68)	1.59 (0.80, 2.37)	1.33 (0.53, 2.14)	1.71 (0.61, 2.82)	
Stroke	0.39 (0.00, 0.78)	0.00 (0.00, 0.00)	0.60 (0.00, 1.27)	0.75 (0.00, 1.56)	1.00 (0.00, 2.39)	
Two or more NCDs	0.46 (0.32, 0.61)	0.39 (0.20, 0.58)	0.53 (0.35, 0.72)	0.45 (0.28, 0.62)	0.50 (0.29, 0.71)	

*The reported average number of overnight hospital admissions (95% CI) for the sample based on each subgroup and variable. Also shown are average overnight hospital admissions (95% CI) for each variable for individuals reporting the 3 most prevalent NCDs. * indicates statistically different from No-NCDs at significance level [alpha] < 0.05.*

The hospitalisation rates were modelled as the dependent variable in several explorative regression models. Specifically, an ordinary least square (OLS), Poisson and negative binomial regressions were constructed to explore the association between NCDs and hospitalisation rate while adjusting for demographic and health covariates. Findings across all models consistently showed an association between NCDs and a higher risk of hospital admission. The results of the three regressions are reported in Table 4. All models agreed in terms of magnitude, directionality, and significance of the associations from the data. However, we only discuss the findings from the negative binomial model as fit measures indicate a strong match with observed data (comparisons of fit are reported in Appendix).

The hospital admission incidence rate ratio (IRR) associated with hypertension was 1.752 (95% CI: 1.017, 3.049). In other words, a hypertension diagnosis was associated with 75 percent higher hospital admission rates compared to individuals with no hypertension, all else equal (p-value =0.01). This constitutes the most considerable burden, provided hypertension is the most prevalent NCD observed in the data. Additionally, being diagnosed with heart disease or angina was associated with the highest hospital admissions increase based on the models. Specifically, hospital admissions for individuals that reported being diagnosed with heart disease or angina were 495 percent higher (IRR = 5.95, p-value < 0.001). There is also suggestive evidence that obesity can be associated with higher rates of hospitalisations, as seen in the Poisson model (IRR = 1.30, p-value < 0.05).

Table 4: Regression Models on Count of Hospital Admissions during the Last 12 Months.

	Ordinary Least Squares		Poisson		Negative Binomial	
	Coeff.	95% CI	IRR	95% CI	IRR	95% CI
Predisposing factors						
Gender (male)	-0.033	-0.127, 0.061	0.853	0.642, 1.126	0.778	0.492, 1.226
Age (ref: 30–49)						
18–29	0.053	-0.043, 0.148	1.356*	1.020, 1.795	1.269	0.827, 1.950
50–69	-0.009	-0.126, 0.108	0.997	0.701, 1.405	1.006	0.592, 1.708
70+	0.209	-0.114, 0.533	2.041*	1.033, 3.787	1.395	0.375, 5.841
Smoking behavior (ref: never)						
Past smoker	-0.081	-0.325, 0.164	0.565	0.216, 1.215	0.722	0.197, 2.498
Current smoker	0.059	-0.059, 0.177	1.369	0.986, 1.884	1.4	0.804, 2.455
Active lifestyle	0.035	-0.047, 0.117	1.223	0.959, 1.557	1.27	0.875, 1.847
Education (ref: high school)						
Secondary school or less	-0.039	-0.146, 0.068	0.818	0.588, 1.131	0.78	0.473, 1.282
College or more	0.037	-0.056, 0.130	1.24	0.943, 1.634	1.123	0.718, 1.755
Employment status (ref: public sector)						
Never worked	-0.008	-0.111, 0.095	0.981	0.721, 1.332	0.977	0.599, 1.595
Private sector	0.013	-0.120, 0.146	1.088	0.722, 1.615	1.034	0.539, 1.990
Retired	-0.001	-0.140, 0.139	0.969	0.653, 1.416	0.955	0.509, 1.796

Enabling factors						
Nationality (ref: Kuwaiti)						
Non-Kuwaiti	-0.034	-0.133, 0.064	0.79	0.581, 1.061	0.653	0.402, 1.057
Wealth (ref: median)						
Lowest quintile	-0.083	-0.211, 0.045	0.671*	0.474, 0.940	0.68	0.384, 1.203
Low quintile	-0.168**	-0.291, -0.045	0.403***	0.266, 0.593	0.430**	0.239, 0.767
High quintile	-0.085	-0.203, 0.034	0.696*	0.508, 0.948	0.704	0.421, 1.176
Highest quintile	-0.140*	-0.260, -0.020	0.512***	0.363, 0.714	0.489**	0.284, 0.836
Need factors						
NCDs						
Obesity	0.053	-0.029, 0.135	1.300*	1.024, 1.647	1.268	0.871, 1.849
Hypertension	0.117	-0.013, 0.248	1.598**	1.146, 2.208	1.752*	1.017, 3.049
Diabetes	0.061	-0.071, 0.193	1.341	0.950, 1.872	1.237	0.701, 2.194
Asthma	-0.011	-0.134, 0.113	0.981	0.697, 1.353	1.082	0.623, 1.889
Chronic lung condition	0.127	-0.097, 0.351	1.477	0.902, 2.319	1.096	0.423, 2.948
Heart disease or angina	0.919***	0.668, 1.170	5.848***	4.103, 8.198	5.948***	2.502, 16.285
Stroke	-0.392	-0.963, 0.178	0.276	0.015, 1.282	0.728	0.025, 15.648
Constant	0.192**	0.058, 0.325	0.163***	0.111, 0.236	0.189***	0.106, 0.340
Observations	1,683		1,683		1,683	
Log likelihood	-2,014.99		-917.616		-734.401	
Theta			0.153*** (0.022)			
Akaike information criterion	4,079.98		1,885.23		1,518.80	

Summary of coefficients from three regression models on the number of yearly admissions for individuals using (1) linear regression, (2) Poisson regression, (3) negative binomial regression, and (4) negative binomial regression with an interaction.

Aside from NCDs, model findings suggestively indicate that all else equal, the highest wealth quintile was associated with a 51.1 percent lower hospital admission rate compared to individuals in the middle wealth quintile (IRR = 0.498; 95% CI: 0.284, 0.836; p-value = 0.02). Similarly, the low wealth quintile was associated with a significant reduction in hospital admission risks (IRR = 0.43, 95% CI: 0.239, 0.767). Effectively, being further away from either end of the median wealth group is associated with a lower hospitalisation rate.

The above findings were consistent across all the constructed models. Interaction terms were iteratively examined, but none resulted in a statistically significant coefficient or improvement in deviance statistic. The Poisson regression showed overdispersion, justifying the need for the negative binomial model which indeed was the better fit. A negative binomial showed that the number of true zeros is not different from the number of predicted zeros, making a zero-inflated negative binomial unnecessary. A zero-inflated negative binomial regression model was constructed to verify and was not significantly different from the negative binomial model.

Discussion

The analysis found that approximately 12 percent of individuals reported being admitted to a hospital in the last 12 months. On average, the hospital admission rate was 0.206 admission pppy. The prevalence of NCDs and the associated risks of hospitalisations in Kuwait are alarming. We found that more than 25% of individuals in Kuwait reported having at least one NCD, and nearly 40% of the sample are obese. Models and group comparisons show sharply elevated hospital admissions risks for individuals with hypertension, diabetes, and heart diseases. In some instances, the increased risk of hospitalisations was four-fold for some subgroups. The quantified risk of hospitalisation carries broad policy implications by serving as a baseline risk for interventions and disease management programmes.

For individuals with no NCDs, the average hospital admission rate was 0.147 pppy. Individuals with any of the three most prevalent NCDs reported statistically significant higher admission rates (Hypertension: 0.44 admissions pppy, Diabetes: 0.35 admissions pppy, and Asthma: 0.32 admissions pppy; Vs. No NCD: p-values < 0.05). The prevalence of hypertension and diabetes increases in older respondents, which means age may confound the relationship between NCD diagnoses and hospital admissions. Expectedly, quitting smoking and physical activity had a protective association against hospitalisations when individuals report NCDs compared to smokers and non-active individuals with the same NCDs. The sharply elevated hospitalisation rates associated with NCDs reported in these findings call for an urgent examination of disease-specific risks for effective allocation of preventative resources.

Explorative regressions models showed a strong and consistent association between NCDs and hospital admission risk across all modes. The directionality of the associations from the regression models in Table 4 agreed with the findings from the group analysis in Table 3. Hypertension was associated with a nearly 75 percent increase in hospital admission rates than similar individuals with no hypertension. Interestingly, age was not

associated with increased admission rates for individuals when adjusting for NCDs. More wealth was also found to be protective against hospital admissions, and the second-lowest wealth quintile was also found to be associated with lower hospital admission risks. The lower wealth associated with fewer hospital admissions was an unexpected finding in this analysis. The interplay between SES and other demographic factors and NCD hospitalisation risks reported in these findings call designated studies into determinants of hospitalisation for individuals with NCDs.

The negative binomial regression model performed significantly better than other regression models to study the number of yearly hospitalisations. The model-predicted zeros were not found to differ from the observed 0 in the outcome variable, eliminating the need for zero-inflated negative binomial models. No interaction terms were found iteratively after exploring potential interactive effects, as shown by the group analysis. Specifically, the interaction effect between the most prevalent NCDs and the interaction effect between NCDs, wealth quintile, and age groups were explored. No interactions were significant, indicating a stable regression model that behaves consistently across various modelling structures.

Missing hospital admission responses were very common in WHS–Kuwait, with approximately 43 percent of the respondents not providing the number of overnight hospital admissions. This raises many concerns about the robustness of the findings due to the reduced sample size and non-random missing values. Preliminary comparisons of NCD prevalence and demographics between available and missing admission data indicate potential non-random patterns of missing data. Appendix B shows the frequency of missing values for the whole WHS–Kuwait sample and the study sample (respondents that provided admission responses). The completeness of future data collection and surveillance studies must be optimised to capture health utilisation assessments.

Still, findings from the model are comparable to hospitalisation risks for NCDs found from other methods and data sources. Published studies and this study's findings found strong associations between NCDs and inpatient hospital admissions. A study of a panel of 11,817 individuals in China found that each additional NCD was associated with a 38% increase in inpatient days.[19] Another study that uses a similar approach on the Serbian National Health Survey included 13,765 adults, found that each additional NCD is associated with a 60 percent increase for males.[20] Estimates from literature are comparable to findings of this study, notwithstanding the difference in methodology and specificity, as this study aims to identify the risk associated with each NCD rather than counts of conditions.

[19] Yang Zhao et al., 'Physical Multimorbidity, Health Service Use, and Catastrophic Health Expenditure by Socioeconomic Groups in China: an Analysis of Population-based Panel Data', *The Lancet Global Healt*h 8/6 (2020), pp. 840–9.

[20] Jankovic J. et al., 'Association Between Non-communicable Disease Multimorbidity and Health Care Utilisation in a Middle-income Country: Population-based Study', *Public Health* 155 (2018), pp. 35–42.

Conclusion

Elevated hospitalisation risks associated with NCDs call for an urgent shift of resources to mitigate the subsequent morbidity, mortality, and burden on Kuwait's curative health services. Baseline estimates show that individuals with hypertension require nearly double the medical resources. In our study findings, individuals with heart disease or angina face almost five times the risk of hospitalisations as individuals without the condition. Interventions targeting modifiable risk factors, disease management strategies, and health-in-all-policies are considered pressing necessities in the wake of evident NCDs' risks.[21]

The estimates obtained from this analysis have vast implications for healthcare planning in Kuwait and the region. This study's nationally representative sample provides a unique perspective on NCDs and hospitalisation risks that have not been previously reported. However, the data has several shortcomings, including dated survey, missing values, and bias in self-reported hospitalisations and NCD diagnoses. While self-reported NCD diagnoses are known to be susceptible to downward bias, we suspect that self-reports of overnight hospitalisations during the last year are less prone to recall biases due to their gravity.[22] Still, self-reported health measures have been used extensively in epidemiologic studies. It derives its validity based on its association with subsequent morbidity and mortality.[23] Despite the limitations in this data source, the approach may be considered the best available to answer a critical question in the wake of inadequate national-level administrative data that deem it challenging to quantify NCD-related hospital services directly.

Our findings have broader implications for the GCC region. Countries in the region share similar lifestyle-related NCDs profiles and potentially similar associated risks of hospitalisations. In the UAE, for example, around 30 percent of residents have hypertension, while the prevalence of hypertension in Saudi Arabia is 26.1 percent.[24] In the wake of recent reforms to control health spending in the GCC, governments are looking to shrink the disproportionately higher hospital spending portion of health budgets.[25] NCDs offer a targetable opportunity to control spending based on findings from our study.

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[21] Nugent et al., 'Investing in Non-communicable Disease Prevention and Management to Advance the Sustainable Development Goals'.

[22] Hanna Tolonen et al., 'Under-estimation of Obesity, Hypertension and High Cholesterol by Self-reported Data: Comparison of Self-reported Information and Objective Measures from Health Examination Surveys', *European Journal of Public Health* 24/6 (2014), pp. 941–8.

[23] Peter Franks, Marthe R Gold and Kevin Fiscella, 'Sociodemographics, Self-rated Health, and Mortality in the US', *Social Science & Medicine* 56/12 (2003), pp. 2505–14.

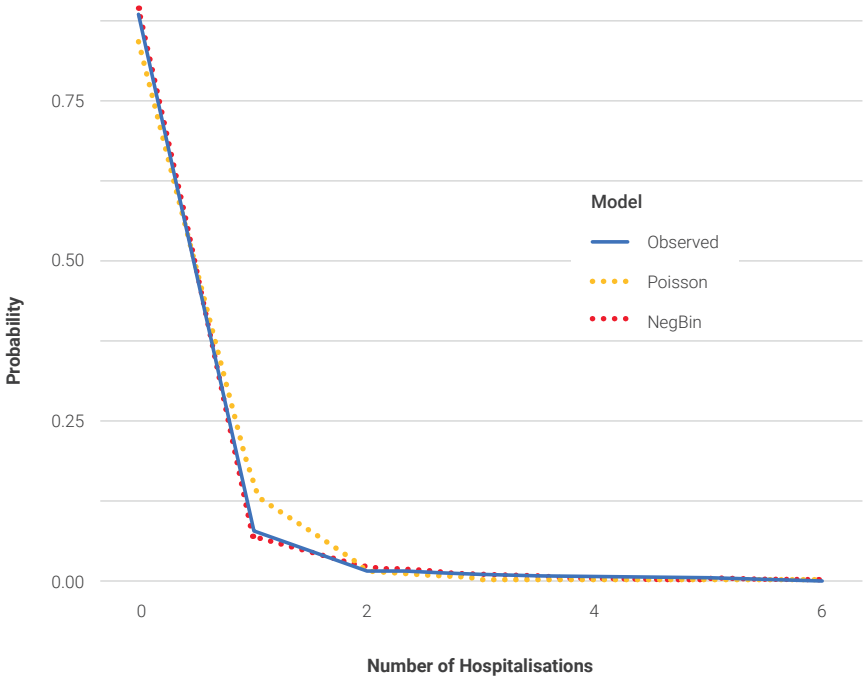
[24] 'Around 30% of UAE Residents Have Hypertension, Studies Show', *Gulf News*. Available at: https://gulfnews.com/uae/health/around-30-of-uae-residents-have-hypertension-studies-show-1.2279535 (accessed 12 April 2021); Mansour M Al-Nozha et al., 'Hypertension in Saudi Arabia', *Saudi Medical Journal* 28/1 (2007), p. 77.

[25] Abdulwahab A. Al Khamis, 'Framing Health Policy in the Context of Saudi Arabia', *Journal of Infection and Public Health* 9/1 (2016), pp. 3–6; Abdulwahab Alkhamis, Amir Hassan and Peter Cosgrove, 'Financing healthcare in Gulf Cooperation Council Countries: a Focus on Saudi Arabia', *The International Journal of Health Planning and Management* 29/1 (2014), pp. 64–82.

The methods applied in this research represent a readily available and general approach to quantify NCD-related hospitalisation risks in countries with slower adoption of health information systems. Since more than 70 countries have adopted the WHS, there is a clear opportunity to conduct a standardised cross-country comparative assessment of hospital admission risks associated with NCDs. Estimates can serve as baselines then be studied over time from subsequent iterations of the WHS to refine strategies towards accomplishing the NCD-related SDGs.

Appendix

Regression Model Fits to Observed Hospitalisation Rates



The visualisation captures the goodness-of-fit of the different model structures employed in this analysis. The closer the model is to the observed the values, the better the better a model fits the data.

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Publications Editor
Amira Djuric

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