ACHSM Asia-Pacific Journal of Health Management

RESEARCH ARTICLE

IMPACT OF HYPERTENSION ON DISABILITY PREVALENCE AND HEALTHCARE COST PROJECTIONS AMONG THAI OLDER ADULTS BY 2040

Utoomporn Wongsin[1], Tuo-Yu Chen[2], Arnat Wannasri[3,4], Thu Win Kyaw[2]*

1. Department of Public Health Administration, Faculty of Public Health, Mahidol University, Bangkok, Thailand
2. Global Health and Health Security Program, College of Public Health, Taipei Medical University, Taipei, Taiwan
3. International Health Program, National Yang Ming Chiao Tung University (NYCU), Taipei, Taiwan
4. Nopparat Rajathanee Hospital, Bangkok, Thailand

*Correspondence: utoomporn.won@mahidol.ac.th

ABSTRACT

BACKGROUND:

Disability poses significant challenges for individuals, families, and societies, leading to diminished quality of life. Hypertension is notably linked to disability among older adults. This study aimed to estimate the prevalence of disability and future healthcare costs among community-dwelling older adults with hypertension in Thailand from 2022 to 2040.

METHOD:

Data were obtained from the Health, Aging, and Retirement in Thailand (HART) survey, official government data, and published papers. The regression model was used to estimate the prevalence of disability among older adults. The micro-costing method was used to obtain the actual hospital service costs incurred for hypertensive patients. Then, the service costs of older adults with hypertension and the consumer price index were used to project future healthcare expenses.

RESULTS:

Thailand's population of older adults aged 60 years or older is projected to increase from 15.77 million in 2022 to 24.04 million in 2040. Approximately 46% of those had hypertension. The prevalence of disability among community-dwelling older adults with hypertension in Thailand ranged from 22-33%, and the incidence ranged from 11-18% by age group. There are an estimated 1.13 million older adults with hypertension and disability in 2022, and this number is forecasted to increase to 1.91 million by 2040. Disability-related healthcare expenditures among community-dwelling older adults with hypertension in Thailand are estimated to be USD 70.72 million in 2022 and are forecasted to reach USD 152.80 million by 2040.

CONCLUSIONS:

This study sheds light on the anticipated health burden faced by community-dwelling older adults with hypertension and disability, along with the associated healthcare costs in Thailand. These findings provide valuable insights for policymakers in formulating service provision strategies and budgetary planning at the national level.

KEYWORDS

older adults with hypertension, disability, healthcare cost projection, Southeast Asia.

INTRODUCTION

Disability refers to a person being unable to complete activities of daily living or/and instrumental activities of daily living due to physical or mental health conditions [1–6]. Disability not only profoundly affects individuals but also affects families and society as a whole. For example, disability is associated with an increased risk of mental health [7,8], reduced physical activity [9], and a strong negative effect on quality of life, leading to long-term care and mortality. [10] Disability can also impose additional financial and caregiver burdens. For instance, taking care of individuals with disability increases depressive symptoms [11,12]. Another study demonstrated that the degree of caregiver burden was affected by the functional status of the care recipient, in which a caregiver caring for a disabled person with a disability experienced a severe degree of caregiver burden. [13] Caregiving can increase the financial strain on the family [1,14–16].

Hypertension is highly prevalent among older adults, making it one of the most common chronic conditions that they experience [17–24]. Hypertensive older adults have an increased risk of developing a disability. Previous studies have shown that hypertension increases the occurrence of disability [18,19]. In addition, the chance of developing disability among individuals increased with age [25]. Several studies have investigated disability among older adults with hypertension.[18,19,25,26]. The prevalence of disability among older adults varies among countries such as 39.2% in India [27], 24.7% in Malaysia [28], 15.3% in Taiwan [29], 35% in Australia, and 36.5% in Thailand [30]. Globally, studies show that approximately 15–30% of hypertensive older adults experience some form of disability, highlighting the global burden of this comorbidity.

Given the high prevalence of hypertension and disability, financial projections are tools used by policymakers to manipulate service provision and budgeting allocation, as well as to monitor financial status [31,32]. Financial projections also aid in developing well-informed policies.[33] For instance, a study of long-term care expenditure projections in Thailand showed that long-term care expenses for the next 10 years would reach 0.80 percentage points of GDP or 3.83 percentage points of government revenue, suggesting that expenditures on community-based long-term care would be affordable for Thai governments [34]. To date, no projection has been made to understand the future prevalence of disability and healthcare costs among hypertensive older adults in Thailand. Hence, the objectives of our study were to estimate (1) the prevalence of disability and (2) associated healthcare costs for community-dwelling older adults with hypertension in the future, providing evidence-based recommendations to government agencies in Thailand. Although several studies in Thailand have estimated the current costs of hypertension or long-term care, these studies have primarily focused on cross-sectional cost estimation or specific healthcare services and have not quantified the future burden associated with disability among hypertensive older adults. Previous Thai projection studies have also largely examined long-term care expenditures at the population level without integrating disease-specific epidemiological data with actual healthcare service costs. The present study addresses this evidence gap by integrating nationally representative epidemiological data from the HART survey, United Nations population projections, and actual provider cost data derived from Thai community hospitals into a single projection framework. Unlike previous Thai costing studies that estimated current expenditures, this study projects both the future prevalence of disability and the corresponding healthcare costs among community-dwelling older adults with hypertension through 2040. This forward-looking approach provides evidence to support long-term resource allocation, budget planning, and preventive policy development in Thailand's ageing society.

METHODS

DATA

Data on hypertension and disability incidence were obtained from the Health, Aging, and Retirement in Thailand (HART) survey (wave-1 [2015] and wave-2 [2017]) [35]. The data are available for academic users from the website of the Center for Aging Society Research (CASR), NIDA, Thailand, at http://rc-demo.nida.ac.th/casr/. In addition, population projection data from 2022 to 2040 were obtained from the Department of Economic and Social Affairs, United Nations [36]. The cost of hypertension among older adults per person-year was obtained from a published paper. The original study estimated

healthcare costs using a traditional costing approach combined with the cost to charge ratio (CCR) method. Hospital costs were categorized into labor, material, and capital cost while indirect costs were allocated from supporting service departments using allocation criteria. The CCR for each service category was derived by dividing total costs by total charges and applied to patient billing records to estimate the actual cost of services. Unit costs per visit and annual costs per patient were then calculated by dividing total costs by the number of visits and patients with hypertension [37]. Data on the consumer price index (CPI) from 2010–2020 were obtained from the Bank of Thailand [38]. This secondary data analysis was approved by the ethics review board at Taipei Medical University (TMU-JIRB: N202304033).

FUTURE CASES AND COST PROJECTION:

1. The total number of older adults in Thailand from 2022 to 2040 was obtained from the Department of Economic and Social Affairs, United Nations.
2. Estimation of the number of older adults with hypertension in Thailand based on the prevalence of hypertension by age groups in 2017 from the HART study.
3. Estimate the prevalence of disability among older adults with hypertension for each age group using logistic regression. The model accounted for potential risk factors including age, number of chronic conditions, obesity status, and baseline disability. These factors were statistically significant predictors in our earlier study [26]. Our current analysis used marginal effects to quantify how each factor influenced disability rates across age groups. The logistic regression model included age, sex, number of chronic conditions, obesity status, and baseline disability. Model fit was evaluated using the Hosmer–Lemeshow test ($p>0.05$) and pseudo R2 (0.21), indicating acceptable validity. Disability was defined as having difficulty in performing at least one Activity of Daily Living (ADL) item in the HART survey, which includes dressing, grooming, bathing, eating, incontinence of bladder and bowel. The logistic regression model can be expressed as: $\text{logit}(P(\text{disability})) = \beta0 + \beta1(\text{age group}) + \beta2(\text{sex}) + \beta3(\text{obesity}) + \beta4(\text{number of chronic conditions}) + \beta5(\text{baseline disability})$, where female sex, non-obesity, and the absence of baseline disability were used as the reference categories.
4. Multiply the number of hypertensive adults with disability in year t by the (constant) disability prevalence rate to get the number of hypertensive adults still with a disability in year t+1.
5. Multiply the number of hypertensive adults without disability in year t by the (constant) disability incidence rate to get the number of hypertensive adults newly with a disability in year t+1.
6. Added step 4 and 5 to get the total number of hypertensive adults in year t+1 with a disability.
7. Followed similar steps (repeat 3-5) for the projected years.
8. Assign healthcare costs per year by multiplying the total number of older adults living with hypertension and disability by the cost of hypertension among older outpatient services from a published paper [38]. Future healthcare costs are adjusted by the lower-bound, mean, and upper-bound of the consumer price index (CPI).

ASSUMPTIONS

The projection is intended as a baseline estimate rather than a forecast of intervention-adjusted outcomes. Healthcare costs were calculated from a provider's perspective were based on data from community hospitals in Thailand. The assumptions of this analysis were as follows: 1) healthcare costs are assumed to be constant with an increase due to the consumer price index (CPI) throughout the projected period; and 2) disability prevalence and incidence rate among community-dwelling older adults with hypertension are assumed to be constant. Although this assumption may not fully reflect future epidemiological changes, it is commonly adopted in long-term healthcare expenditure projection studies when reliable forecasts of future disease trends are unavailable. This approach isolates the impact of population ageing on healthcare demand while avoiding speculative assumptions regarding future hypertension management, behavioural risk factors, and policy changes. Therefore, the estimates should be interpreted as a baseline projection scenario.

Microsoft Excel and Stata version 18 MP (Stata Corp LP, College Station, TX, USA) were used for data analysis and projection.

A SENSITIVITY ANALYSIS

One-way sensitivity analysis was performed to evaluate the robustness of the projected healthcare costs under alternative assumptions. Disability prevalence was selected as the key parameter because it directly determines the projected

number of older adults with hypertension and disability and, consequently, the total healthcare expenditure. In the sensitivity analysis, disability prevalence was varied by ±20% while all other model parameters were held constant. The projected number of older adults with hypertension and disability and the total healthcare costs were then recalculated for each scenario (see Supplementary Table and Figures: eTable 3, eFigure 2 to eFigure 5).

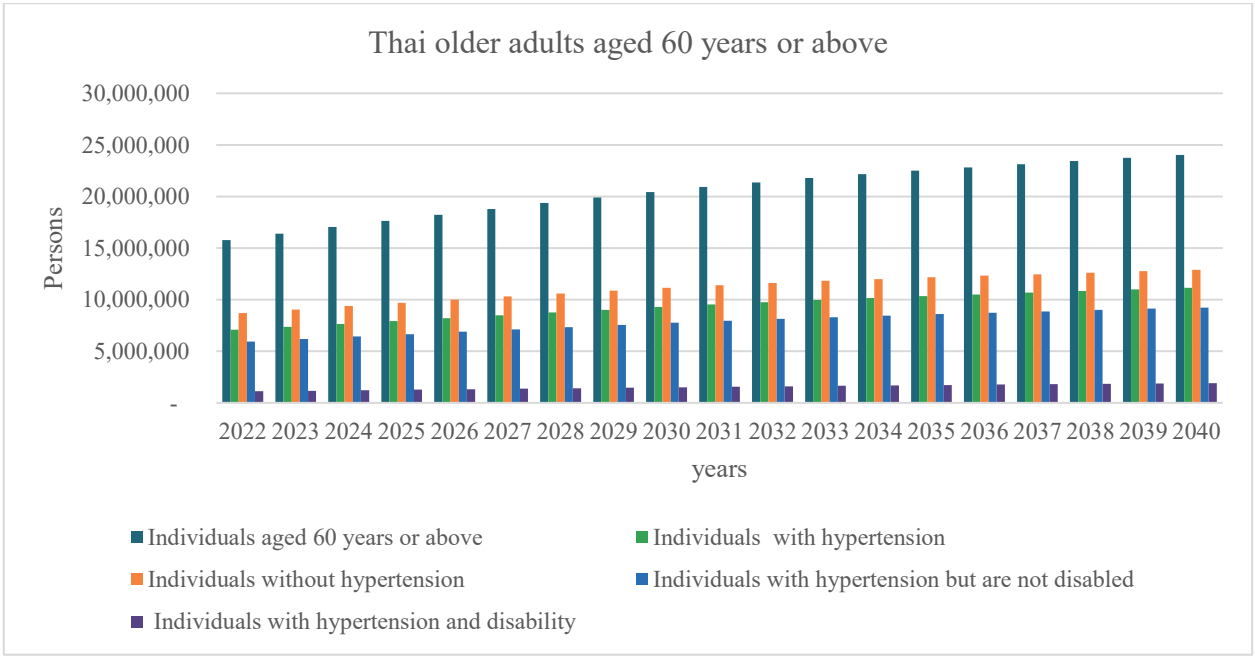
A ±20% variation was selected as a plausible uncertainty range because parameter-specific measures of uncertainty, such as confidence intervals for the projected prevalence and incidence estimates, were unavailable. Deterministic one-way sensitivity analysis using a plausible range of parameter values is a widely accepted approach for assessing uncertainty in health economic modelling. Therefore, the purpose of the ±20% variation was to evaluate the robustness of the projections rather than to represent statistical confidence limits [39,40]. The robustness of the findings was assessed by comparing the results of the sensitivity analyses with those of the base-case analysis.

RESULTS

PARTICIPANTS WERE THAI OLDER ADULTS AGED 60 YEARS OR ABOVE.

Figure 1 provides information about older adults aged 60 years or older in five main groups: 1) individuals aged 60 years or older according to the United Nations, 2) individuals without hypertension, 3) individuals with hypertension, 4) individuals with hypertension but who are not disabled, and 5) projected older adults with hypertension and disability. The results showed that the number of projected older adults in the five groups is forecasted to increase by 2040. Specifically, according to information from the United Nations, there will be 24.03 million older adults in Thailand who are 60 years of age and older by 2040. Based on the constant prevalence and incidence rate assumption (eTable 1), the number of individuals with hypertension is estimated to be 7.07 million people in 2022 and is projected to reach 11.15 million people by 2040. Among individuals with hypertension, those with hypertension but who were not disabled were estimated to be 4.82 million people in 2022 and are expected to reach 9.24 million people by 2040. Additionally, the number of older adults with hypertension and disability is estimated to be 1.13 million people in 2022 and is projected to reach 1.91 million people by 2040.

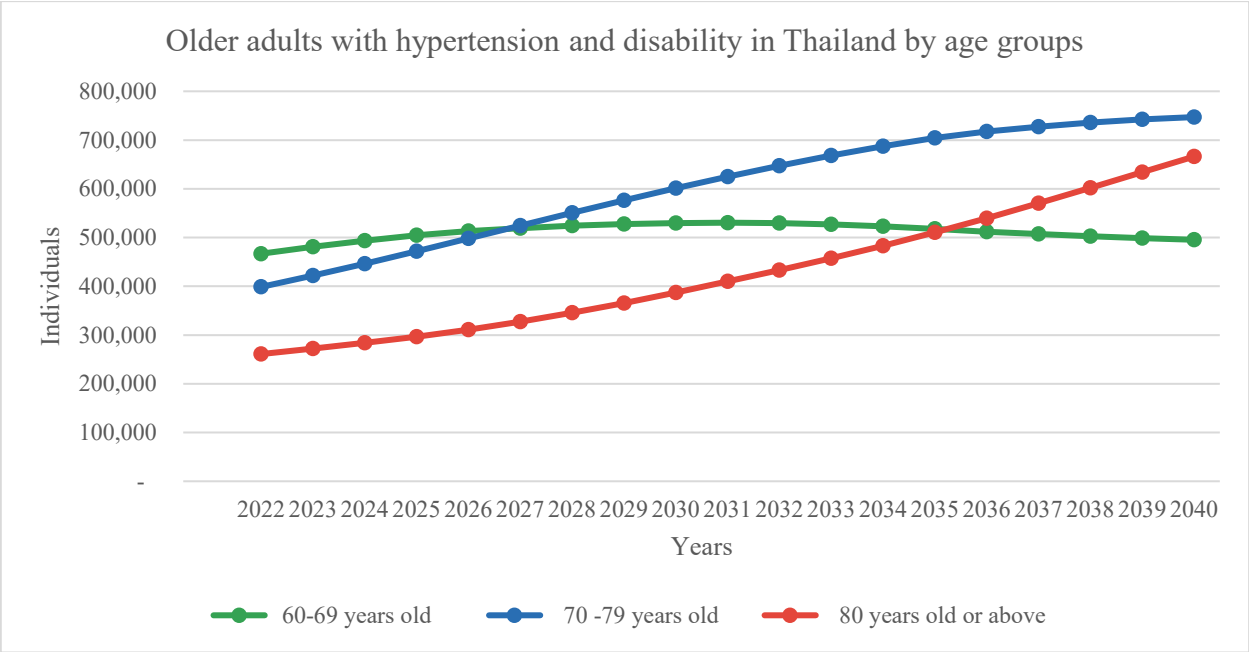
FIGURE 1. PROJECTED OLDER ADULTS AGED 60 YEARS OLD OR ABOVE IN THAILAND



PROJECTED OLDER ADULTS WITH HYPERTENSION AND DISABILITY IN THAILAND BY AGE GROUPS

Figure 2 presents information from a projection of older adults with hypertension and disability by age groups. The results showed that the number of older adults with hypertension and disability aged 70–79 years is forecasted to reach more than 0.75 million by 2040, which is the highest age group. Specifically, the number of older adults aged 60–69 years with hypertension and disability was estimated to be 0.46 million in 2022 and is projected to increase gradually to 0.50 million by 2040. Moreover, the number of older adults with hypertension and disability between the ages of 70 and 79 was estimated to be 0.39 million in 2022 and is projected to grow moderately to 0.75 million by 2040. While the number of older adults with hypertension and a disability aged 80 years or older was estimated to be 0.26 million in 2022, it is projected to increase to 0.66 million by 2040.

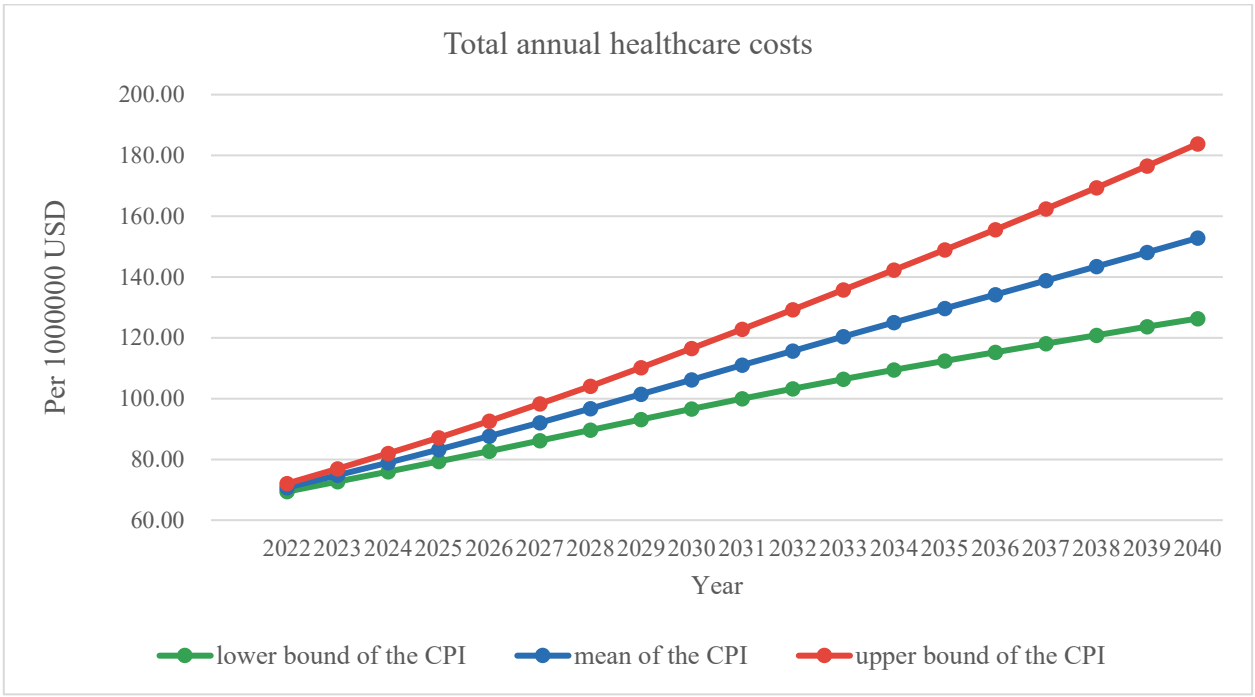
FIGURE 2. PROJECTED OLDER ADULTS WITH HYPERTENSION AND DISABILITY IN THAILAND BY AGE GROUPS



PROJECTED TOTAL ANNUAL HEALTHCARE COST FOR COMMUNITY-DWELLING OLDER ADULTS WITH HYPERTENSION IN THAILAND

Figure 3 shows the results of the projection of total healthcare costs. The results show that disability-related healthcare expenditures among community-dwelling older adults with hypertension in Thailand are estimated to increase sharply over the study period. The mean projected annual healthcare costs are forecasted to reach USD 80 per capita by 2040 (eFigure 1). Specifically, the lower annual healthcare costs were estimated at USD 69.38 million in 2022 and are predicted to increase to USD 126.30 million by 2040. In addition, the average annual cost of healthcare was estimated at USD 70.72 million in 2022, and it is projected to increase to USD 152.80 million by 2040. The upper annual healthcare costs are estimated to reach USD 72.03 million in 2022 and are predicted to increase to USD 183.79 million by 2040. Because the projections were generated under constant prevalence and incidence assumptions, they should be interpreted as baseline estimates. Future scenario analyses incorporating improvements in hypertension prevention or control could produce lower projected healthcare expenditures.

FIGURE 3. PROJECTED TOTAL ANNUAL HEALTHCARE COSTS



Note. CPI = Consumer Price Index. Exchange rate 35THB=1USD [41]

DISCUSSION

This is the first study to determine the projected prevalence and healthcare costs of disability among community-dwelling older adults with hypertension in Thailand from 2022–2040. Moreover, the significance of our study is utilizing actual cost information in the analysis. Our projection demonstrated that the prevalence of disability among community-dwelling older adults with hypertension in Thailand ranged from 22-33% by age group. The incidence of disability among community-dwelling older adults with hypertension in Thailand ranged from 11-18% by age group. The prevalence and incidence of disability are assumed to be constant over time. The number of older adults with hypertension and disability is estimated to increase from 2022 to 2040, a 43% increase. The mean total healthcare costs were projected to increase by 54 % from 2022 to 2040. To our knowledge, this is the first Thai study to integrate nationally representative epidemiological data, actual provider cost information, and population projections to estimate the future burden of disability and healthcare costs among community-dwelling older adults with hypertension. Previous Thai studies have generally reported current treatment costs, disease prevalence, or long-term care expenditures separately, whereas our study combines these data sources within a projection framework to estimate future healthcare needs through 2040. This integrated approach provides policymakers with evidence not only on the current economic burden but also on the anticipated magnitude and timing of future service demand resulting from population ageing.

PREVALENCE OF DISABILITY PROJECTION

The findings presented in Figures 1 and 2 highlight a concerning trend in the projected increase in the number of older adults aged 60 years or older, especially those affected by hypertension and disability. Alarmingly, within the hypertensive group, the number of individuals without disabilities is expected to increase significantly, and the number of older adults with both hypertension and disabilities is also expected to increase. By 2040, individuals aged 70–79 years are projected to constitute the greatest number. The age groups of 60–69 years and 80 years or older are also expected to increase gradually. These data underscore the imperative for healthcare strategies to address the evolving healthcare needs of aging populations, particularly in managing hypertension and disabilities among older individuals. This is in line with SDG 3, which is good health and well-being, to ensure health and well-being for everyone.

HEALTHCARE COST PROJECTION

We found that the mean annual healthcare costs for older adults with hypertension and disability were estimated at USD 63 in 2022. It will amount to USD 80 per person in 2040, which is higher when the costs are compared to the capitation rate paid for outpatient services by the universal health coverage scheme (UCs) in Thailand. The capitation rate for outpatient services is USD 39 per person in 2023. [42] In addition, it is forecasted to be USD 64 in 2040 based on the average annual growth rate of the capitation rate between 2017 and 2021, which is approximately 3%. The estimates depict a substantial increase from 2022, where lower annual costs were approximately USD 69.38 million, which is expected to increase to USD 126.32 million by 2040. Moreover, the average annual healthcare expenditure, initially USD 70.72 million in 2022, is projected to increase to USD 152.80 million by 2040. These rising costs, as shown in Figure 3 and Supplementary eFigure 1, emphasize the critical need for proactive strategies to manage and mitigate healthcare expenses in Thailand's aging population with hypertension.

Regarding policy related to dependent individuals in Thailand, the National Health Security Office (NHSO) provides a long-term care program that covers Thais of all ages who have difficulty performing activities of daily living (ADL) and who have cognitive impairment.[43] The NHSO allocates an annual budget to the local government for public healthcare and social care (e.g., volunteer, home visit, home modification) that is equal to USD 171 per capita per year in 2023. This allocation is based on the number of dependents in the community. Even though there is an annual budget for long-term care services, it is unknown whether future healthcare costs will exceed the government's budget due to Thailand's rapidly aging population. The results of our projection from 2022 to 2040 suggest that prevention and promotion programs such as community-based hypertension screening, adherence support programs, and rehabilitation services are necessary for this target group to help sustain the Thai insurance scheme in terms of reducing disability risk and long-term costs. These findings may also support budget planning within the Universal Coverage Scheme (UCS), the National Health Security Office (NHSO), and Thailand's Long-Term Care (LTC) programme by identifying future resource requirements for outpatient care, rehabilitation capacity, and community-based preventive services. Strengthening primary care, medication adherence, blood pressure control, and community rehabilitation may delay disability onset and improve the sustainability of the health system.

ASSUMPTION

The projection was intended as a baseline scenario based on the best available empirical data, given the absence of robust nationally representative longitudinal data to support reliable time-varying estimates over the 2022–2040 period. Similar assumptions were observed in previous published studies. Chen Y et al conducted a study in 2023 in which disability incidence among older adults with hypertension is effectively assumed constant over time in the absence of modeled changes, which is a common approach in such Markov or microsimulation models[44]. A similar assumption was observed in the burden-of-disease studies by Liu AB et al that are often cited to justify assuming constant disability rates in analytic models of chronic conditions like hypertension[45].

COMPARISON WITH OTHER STUDIES

However, findings from this study were lower than those from previous studies due to differences in healthcare facility level and income level. For example, a previous study showed that the monthly medical care costs for older adults with functional disabilities in the US were estimated at USD 420 per person in 2022 and are forecasted to reach USD 430 per person in 2030 [46]. Another study showed that in the US, the average annual healthcare expenditure of hypertension for older adults aged 65 or older was USD 778 per person in 2010, which was greater than that for adults aged 18-44 years (USD 636) and aged 45-64 years [47]. In another study, older adults aged 65 years or older with hypertension were forecasted to face more than USD 2,000 in incremental healthcare costs per year compared with those aged 64 years or younger in 2014 [48].

STRENGTHS AND LIMITATIONS

Our findings have practical implications. This study provides information on the prevalence and incidence of hypertension, the proportion of older adults with hypertension and disability, and the total projected annual healthcare costs. The results

suggest the initiation of programs for preventing disability among older adults with hypertension, which will consequently reduce future healthcare costs among target groups.

The constant-rate assumption reflects the absence of robust longitudinal national data on future changes in hypertension control, disability incidence, and disability prevalence among older adults with hypertension in Thailand. We consider it a strength although we acknowledge that this approach likely provides a conservative baseline estimate and may underestimate or overestimate future burden depending on changes in prevention, treatment, and population health dynamics.

This study has limitations. We assumed constant hypertension incidence and constant disability incidence among older adults in our projection. Therefore, our findings are likely to underestimate the number of older adults with hypertension and disability and future healthcare costs. Second, no breakdown by disability severity was possible. Thus, further studies along with different scenarios are recommended to determine the prevalence and incidence rate, which could improve the generalizability of these findings. In addition, improvements in hypertension detection, medication adherence, blood pressure control, and preventive programmes could reduce future disability incidence and healthcare expenditure. Conversely, worsening cardiovascular risk profiles could increase future costs. Furthermore, the projected costs include only outpatient hypertension-related healthcare services from the provider perspective and exclude inpatient care, rehabilitation, assistive devices, home care, long-term care, informal care, and productivity losses because Hypertension is predominantly managed in outpatient settings, and most routine monitoring and treatment occur without hospitalization. Additionally, disability in this study was defined as having difficulty in at least one activity of daily living (ADL). Consequently, our findings are likely to represent conservative estimates of the overall financial burden.

CONCLUSIONS

In conclusion, our study revealed an increasing prevalence of disability and anticipated healthcare expenditures among community-dwelling older adults with hypertension in Thailand. With a projected 41% increase in the number of hypertensive older adults experiencing disability and a 54% increase in associated healthcare costs from 2022 to 2040, urgent action is warranted. Implementing health promotion initiatives and disability prevention programs targeted at this demographic can mitigate disease burdens and alleviate the strain on healthcare resources. Proactive measures are essential to safeguard the well-being of older adults with hypertension, ensuring a healthier and more sustainable future for Thailand's aging population. Community-based screening, adherence support, and rehabilitation were identified as important strategies to reduce disability risk and long-term costs among older adults with hypertension.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

ACKNOWLEDGMENTS

The authors would like to express their gratitude to the Centre for Aging Society Research/Research Centre National Institute of Development Administration (NIDA) for providing HART data.

FUNDING INFORMATION

There was no Funding

COMPETING INTERESTS

The authors declare that they have no competing interests.

References

1. Fried LP, Ferrucci L, Darer J, Williamson JD, Anderson G. Untangling the Concepts of Disability, Frailty, and Comorbidity: Implications for Improved Targeting and Care. J Gerontol Ser A. 2004 Mar 1;59(3):M255–63. doi:10.1093/gerona/59.3.M255
2. Gobbens RJJ, van der Ploeg T. The Prediction of Mortality by Disability Among Dutch Community-Dwelling Older People. Clin Interv Aging. 2020 Oct 5;15:1897–906. doi:10.2147/CIA.S271800
3. Nagi SZ. A Study in the Evaluation of Disability and Rehabilitation Potential. Am J Public Health Nations Health. 1964 Sep;54(9):1568–79.
4. Verbrugge LM. Disability Experience and Measurement. J Aging Health. 2016 Oct 1;28(7):1124–58. doi:10.1177/0898264316656519
5. Verbrugge LM, Jette AM. The disablement process. Soc Sci Med 1982. 1994 Jan;38(1):1–14. doi:10.1016/0277-9536(94)90294-1
6. Palmer M, Harley D. Models and measurement in disability: an international review. Health Policy Plan. 2012 Aug 1;27(5):357–64. doi:10.1093/heapol/czr047
7. Korff MV, Katon WJ, Lin EHB, Ciechanowski P, Peterson D, Ludman EJ, et al. Functional outcomes of multi-condition collaborative care and successful ageing: results of randomised trial. BMJ. 2011 Nov 10;343:d6612. doi:10.1136/bmj.d6612
8. Beurs E de, Beekman ATF, Balkom AJLM van, Deeg DJH, Dyck R van, Tilburg W van. Consequences of anxiety in older persons: its effect on disability, well-being and use of health services. Psychol Med. 1999 May;29(3):583–93. doi:10.1017/S0033291799008351
9. Ostir GV, Carlson JE, Black SA, Rudkin L, Goodwin JS, Markides KS. Disability in Older Adults 1: Prevalence, Causes, and Consequences. Behav Med. 1999 Jan 1;24(4):147–56. doi:10.1080/08964289.1999.11879271
10. Balzi D, Lauretani F, Barchielli A, Ferrucci L, Bandinelli S, Buiatti E, et al. Risk factors for disability in older persons over 3-year follow-up. Age Ageing. 2010 Jan 1;39(1):92–8. doi:10.1093/ageing/afp209
11. Arai Y, Sugiura M, Washio M, Miura H, Kudo K. Caregiver depression predicts early discontinuation of care for disabled elderly at home. Psychiatry Clin Neurosci. 2001;55(4):379–82. doi:10.1046/j.1440-1819.2001.00878.x
12. Kim D. Relationships between Caregiving Stress, Depression, and Self-Esteem in Family Caregivers of Adults with a Disability.. Occup Ther Int. 2017 Oct 17;2017:1686143. doi:10.1155/2017/1686143
13. Salama RAA, El-Soud FAA. Caregiver burden from caring for impaired elderly: a cross-sectional study in rural Lower Egypt. Italian Journal of Public Health. Vol. 9. 2012;9(4):11. doi:10.2427/8662
14. Antón JI, Braña FJ, Muñoz de Bustillo R. An analysis of the cost of disability across Europe using the standard of living approach. SERIEs. 2016 Aug 1;7(3):281–306. doi:10.1007/s13209-016-0146-5
15. Minh HV, Giang KB, Liem NT, Palmer M, Thao NP, Duong LB. Estimating the extra cost of living with disability in Vietnam. Glob Public Health. 2015;10 Supppl 1:S70-79. doi:10.1080/17441692.2014.971332
16. Mitra S, Palmer M, Kim H, Mont D, Groce N. Extra costs of living with a disability: A review and agenda for research. Disabil Health J. 2017 Oct 1;10(4):475–84. doi:10.1016/j.dhjo.2017.04.007
17. Li H, Hu YJ, Lin H, Xia H, Guo Y, Wu F. Hypertension and Comorbidities in Rural and Urban Chinese Older People: An Epidemiological Subanalysis From the SAGE Study. Am J Hypertens. 2021 Feb 1;34(2):183–9. doi:10.1093/ajh/hpaa146
18. Chou CY, Chiu CJ, Chang CM, Wu CH, Lu FH, Wu JS, et al. Disease-related disability burden: a comparison of seven chronic conditions in middle-aged and older adults. BMC Geriatr. 2021 Mar 23;21(1):201. doi:10.1186/s12877-021-02137-6
19. Marmamula S, Modepalli SB, Kumbham TR, Challa R, Keeffe JE. Prevalence of disabilities and non-communicable diseases in an elderly population in the Telangana state, India: a population-based cross-sectional study. BMJ Open. 2021 Feb 1;11(2):e041755. doi:10.1136/bmjopen-2020-041755
20. Buford TW. Hypertension and aging. Ageing Res Rev. 2016 Mar 1;26:96–111. doi:10.1016/j.arr.2016.01.007
21. Muli S, Meisinger C, Heier M, Thorand B, Peters A, Amann U. Prevalence, awareness, treatment, and control of hypertension in older people: results from the population-based KORA-age 1 study. BMC Public Health. 2020 Jul 2;20(1):1049. doi:10.1186/s12889-020-09165-8

22. Wu H, Wu J, Zhang Z, Zheng Y, Niu W, Zheng L, et al. Prevalence and Associated Risk Factors of Hypertension in Adults with Disabilities: A Cross-Sectional Study in Shanghai, China. Clin Epidemiol. 2021;13:769–77. doi:10.2147/CLEP.S322791
23. Chang AY, Gómez-Olivé FX, Manne-Goehler J, Wade AN, Tollman S, Gaziano TA, et al. Multimorbidity and care for hypertension, diabetes and HIV among older adults in rural South Africa. Bull World Health Organ. 2019 Jan 1;97(1):10–23. doi:10.2471/BLT.18.217000 PubMed PMID: 30618461
24. Setters B, Holmes HM. Hypertension in the Older Adult. Prim Care. 2017 Sep;44(3):529–39. doi:10.1016/j.pop.2017.05.002
25. Qian J, Ren X. Association between comorbid conditions and BADL/IADL disability in hypertension patients over age 45. Medicine (Baltimore). 2016 Aug 7;95(31):e4536. doi:10.1097/MD.0000000000004536
26. Wongsin U, Chen TY. Sex differences in the risk factors of disability among community-dwelling older adults with hypertension: Longitudinal results from the Health, Aging, and Retirement in Thailand study (HART). Front Public Health. Volume 11-2023. doi:10.3389/fpubh.2023.1177476
27. Prynn JE, Polack S, Mactaggart I, Banks LM, Hameed S, Dionicio C, et al. Disability among Older People: Analysis of Data from Disability Surveys in Six Low- and Middle-Income Countries. Int J Environ Res Public Health. 2021 Jun 29;18(13):6962. doi:10.3390/ijerph18136962
28. Hairi NN, Bulgiba A, Cumming RG, Naganathan V, Mudla I. Prevalence and correlates of physical disability and functional limitation among community dwelling older people in rural Malaysia, a middle income country. BMC Public Health. 2010 Dec;10(1):492. doi:10.1186/1471-2458-10-492
29. Chiu C, Li M, Chang C, Wu C, Tan M. Disability trajectories prior to death for ten leading causes of death among middle-aged and older adults in Taiwan. BMC Geriatr. 2021 Jul 10;21(1). doi:10.1186/s12877-021-02300-z
30. Khongboon P, Pongpanich S, Chapman RS. Risk Factors for Six Types of Disability among the Older People in Thailand in 2002, 2007, and 2011. J Aging Res. 2016;2016:6475029. doi:10.1155/2016/6475029
31. Elliott WJ. The Economic Impact of Hypertension. J Clin Hypertens. 2003;5(3):3–13. doi:10.1111/j.1524-6175.2003.02463.x
32. Jahanmehr N, Noferesti M, Damiri S, Abdi Z, Goudarzi R. The Projection of Iran's Healthcare Expenditures By 2030: Evidence of a Time-Series Analysis. Int J Health Policy Manag. 2022 Jan 11;0. doi:10.34172/ijhpm.2022.5405
33. Cichon M, Newbrander WC, Weber A, Normand CEM, Preker AS, Internationales Arbeitsamt, et al., editors. Modelling in health care finance: a compendium of quantitative techniques for health care financing ; a joint technical publication of the International Labour Office (ILO) and the International Social Security Association (ISSA). Geneva: Internat. Labour Off; 1999. 376 p. (Quantitative methods in social protection series).
34. Prasitsiriphon O, Jege F, Tharachompoo A, Sakunphanit T. Costing Model for Long-Term Care System in Thailand. Health Insurance System Research Office (HISRO),Health Systems Research Institute.; 2013. p. 24.
35. HART – NIDA IIC [Internet]. [cited 2025 Apr 14]. Available from: http://iic.nida.ac.th/main/?page_id=564
36. United Nations, Department of Economic and Social Affairs, Population Division. World population ageing, 2019 highlights. 2020.
37. Wongsin U, Suanrueang P, Chen TYC. Cost analysis of outpatient services for hypertension, heart attacks, and strokes among older adults in community hospitals in Thailand. J Health Syst Res Press. 2023:17(2):317-28. https://he04.tci-thaijo.org/index.php/j_hsr/article/view/3177
38. Bank of Thailand (Statistical Data) EC_EI_027 Thailand's Macro Economic Indicators 1/ [Internet]. [cited 2025 Sep 10]. Available from: https://www.bot.or.th/App/BTWS_STAT/statistics/BOTWEBSTAT.aspx?reportID=409&language=ENG
39. Briggs AH, Gray AM. Handling uncertainty in economic evaluations of healthcare interventions. BMJ. 1999 Sep 4;319(7210):635–8. doi:10.1136/bmj.319.7210.635
40. Briggs A, Sculpher M, Buxton M. Uncertainty in the economic evaluation of health care technologies: The role of sensitivity analysis. Health Econ. 1994;3(2):95–104. doi:10.1002/hec.4730030206
41. Daily Foreign Exchange Rates [Internet]. [cited 2025 Feb 26]. Available from: https://www.bot.or.th:443/english/statistics/financialmarkets/exchangerate/_layouts/application/exchangerate/exchangerate.aspx
42. National Health Security Office (NHSO) [Internet]. [cited 2025 May 20]. Available from: https://eng.nhso.go.th/view/1/Home/EN-US
43. National Health Security Office. www.nhso.go.th [Internet]. [cited 2025 Feb 17]. Long term care systm (LTC). Available from: https://ltcnew.nhso.go.th/

44. Chen Y, Araghi M, Bandosz P, Shipley MJ, Ahmadi-Abhari S, Lobanov-Rostovsky S, et al. Impact of hypertension prevalence trend on mortality and burdens of dementia and disability in England and Wales to 2060: a simulation modelling study. Lancet Healthy Longev. 2023 Sep;4(9):e470–7. doi:10.1016/S2666-7568(23)00129-0
45. Liu AB, Lin YX, Meng TT, Tian P, Chen JL, Zhang XH, et al. Global prevalence and disability-adjusted life years of hypertensive heart disease: A trend analysis from the Global Burden of Disease Study 2019. J Glob Health. 2024:14:04172. doi:10.7189/jogh.14.04172
46. Bhattacharya J, Cutler DM, Goldman DP, Hurd MD, Joyce GF, Lakdawalla DN, et al. Disability Forecasts and Future Medicare Costs. In: Frontiers in Health Policy Research, Volume 7 [Internet]. MIT Press; 2004 [cited 2025 Dec 3]. p. 75–94. Available from: https://www.nber.org/books-and-chapters/frontiers-health-policy-research-volume-7/disability-forecasts-and-future-medicare-costs
47. Davis KE. Expenditures for Hypertension among Adults Age 18 and Older, 2010: Estimates for the U.S. Civilian Noninstitutionalized Population [Internet]. Agency for Healthcare Research and Quality (US), Rockville (MD); 2001.. Available from: http://europepmc.org/abstract/MED/30188652
48. Kirkland EB, Heincelman M, Bishu KG, Schumann SO, Schreiner A, Axon RN, et al. Trends in Healthcare Expenditures Among US Adults with Hypertension: National Estimates, 2003–2014. J Am Heart Assoc. 2018;7(11):e008731. doi:10.1161/JAHA.118.008731

APPENDIX: SUPPLEMENTARY TABLE AND FIGURES

eTable 1: Prevalence and incidence rate of disability by age group

eFigure 1: Total annual healthcare costs per person

eTable 2: The Consumer Price Index (CPI) in Thailand

eTable 3: Prevalence and incidence rate of disability by age groups by ±20%

eFigure 2: Projected older adults with hypertension and disability in Thailand by age groups (by +20%)

eFigure 3: Projected total annual healthcare cost for community-dwelling older adults with hypertension in Thailand (by +20%)

eFigure 4: Projected older adults with hypertension and disability in Thailand by age groups

(by -20%)

eFigure 5: Projected total annual healthcare cost for community-dwelling older adults with hypertension in Thailand (by -20%)

ETABLE 1: PREVALENCE AND INCIDENCE RATE OF DISABILITY BY AGE GROUPS

Age groups	Prevalence rate	Incidence rate
60-69 years old	22.40%	10.95%
70 -79 years old	29.60%	15.24%
80 years old or above	33.30%	17.68%

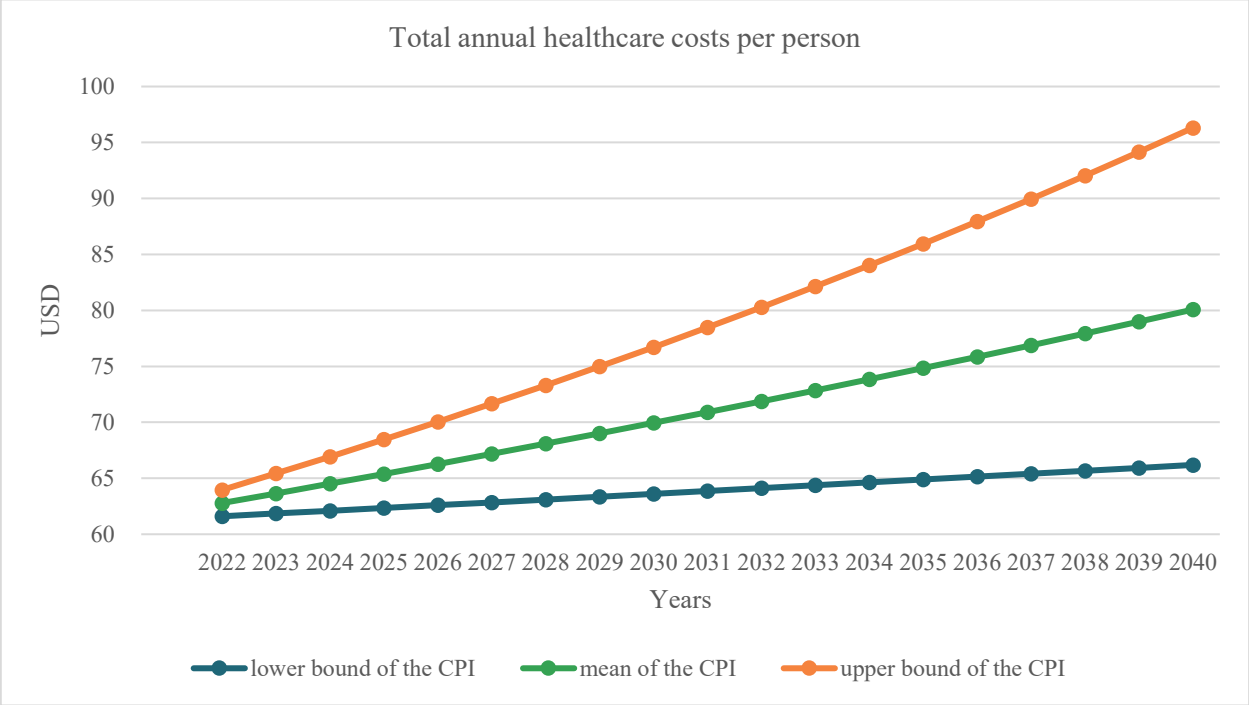
Noted: Stata command for prevalence (margins, at (age_group 2015=0 any_adl_2015==1)

Age groups	Predicted probability (95% CI)	*p*-value
60–69 years	0.224 (0.080–0.368)	0.002
70–79 years	0.296 (0.132–0.459)	<0.001
80 years old or above	0.333 (0.172–0.494)	<0.001

Stata command for incidence (margins, at (age_group_2015=0 any_adl_2015==0)

Age groups	Predicted probability (95% CI)	*p*-value
60–69 years	0.110 (0.076–0.143)	<0.001
70–79 years	0.152 (0.119–0.197)	<0.001
80 years old or above	0.177 (0.133–0.232)	<0.001

EFIGURE 1: TOTAL ANNUAL HEALTHCARE COSTS PER PERSON



Note. CPI = The Consumer Price Index

ETABLE 2. THE LOWER BOUND, MEAN, AND UPPER BOUND OF THE CONSUMER PRICE INDEX (CPI) IN THAILAND FROM 2010 TO 2020

The Consumer Price Index (CPI)	
Upper bound of the CPI	2.30%
Mean of the CPI	1.36%
Lower bound of the CPI	0.40%

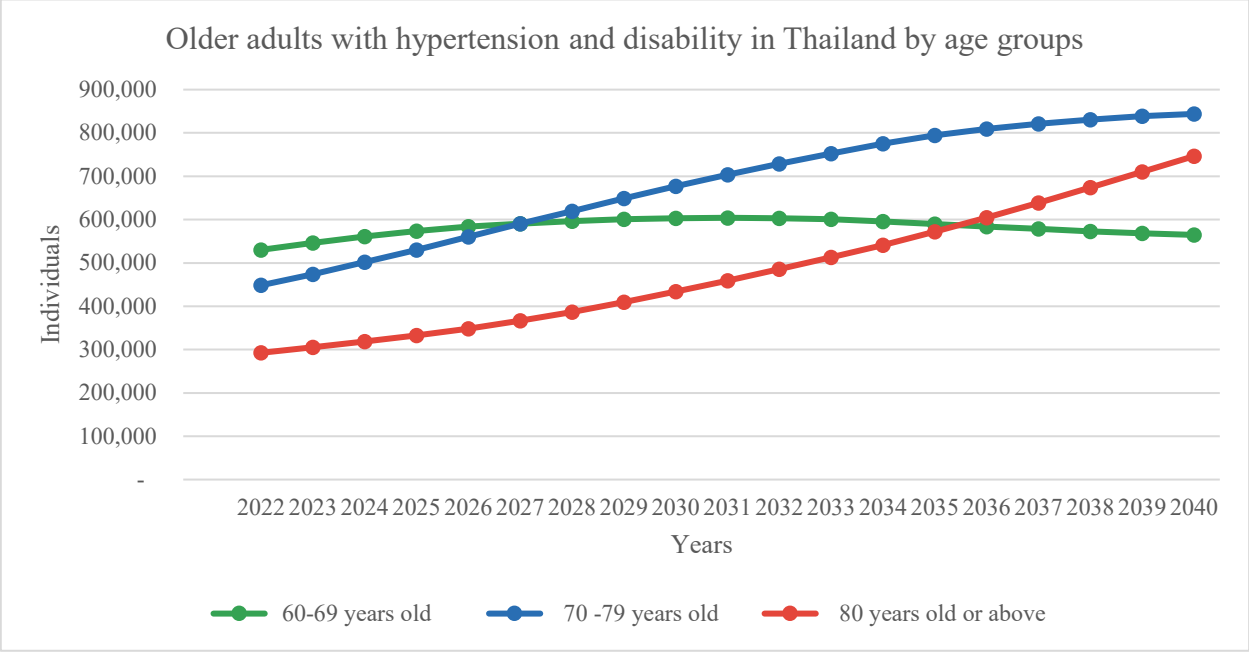
A One-way Sensitivity Analysis of Prevalence of disability (±20%)

One-way sensitivity analysis was performed to evaluate the robustness of the projected healthcare costs under alternative assumptions. Disability prevalence was selected as the key parameter because it directly determines the projected number of older adults with hypertension and disability and, consequently, the total healthcare expenditure. In the sensitivity analysis, disability prevalence by age groups was varied by ±20% while all other model parameters were held constant. The projected number of older adults with hypertension and disability and the corresponding total healthcare costs were then recalculated for each scenario.

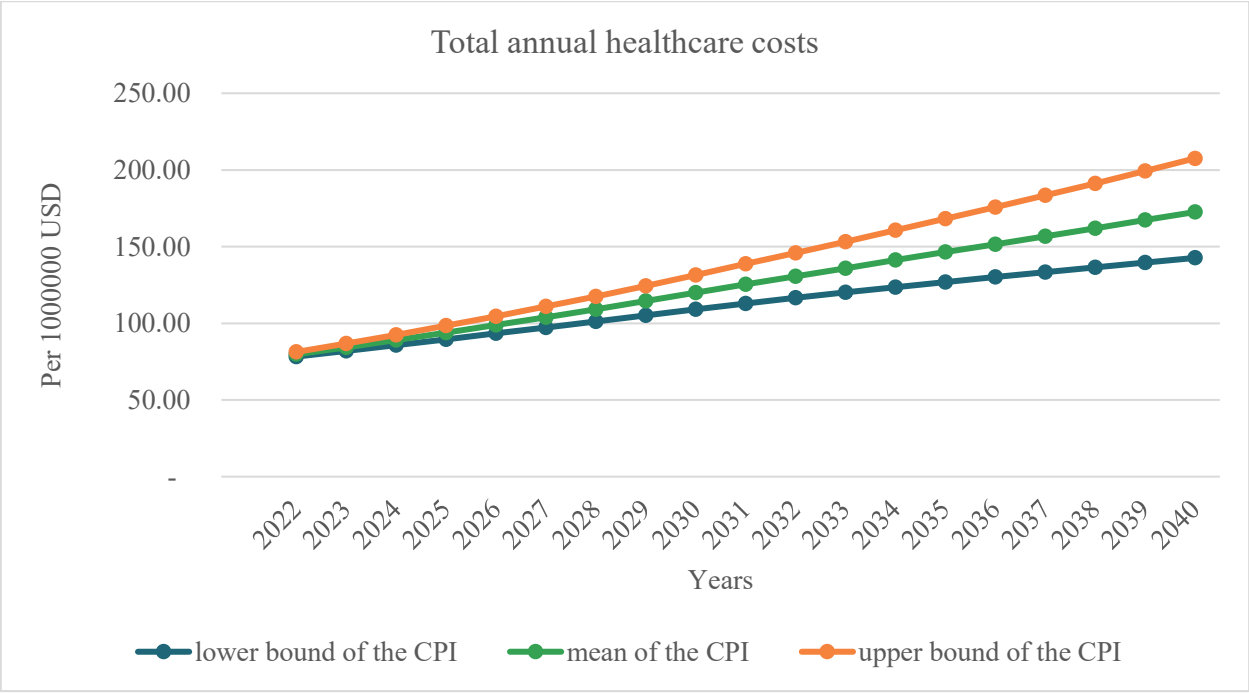
ETABLE 3: PREVALENCE AND INCIDENCE RATE OF DISABILITY BY AGE GROUPS BY ±20%

Age groups	Prevalence rate	Prevalence rate **+20%**	Prevalence rate**-20%**
60-69 years old	22.40%	42.40%	2.40%
70 -79 years old	29.60%	49.60%	9.60%
80 years old or above	33.30%	53.30%	13.30%

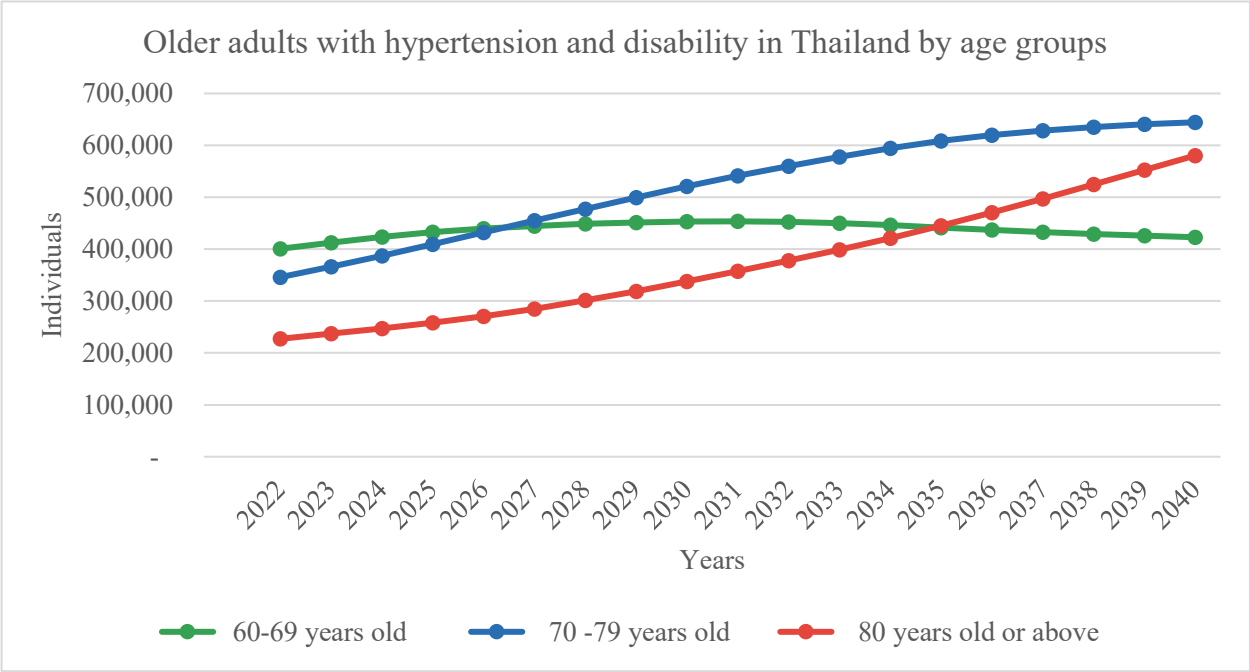
EFIGURE 2: PROJECTED OLDER ADULTS WITH HYPERTENSION AND DISABILITY IN THAILAND BY AGE GROUPS (BY +20%)



EFIGURE 3: PROJECTED TOTAL ANNUAL HEALTHCARE COST FOR COMMUNITY-DWELLING OLDER ADULTS WITH HYPERTENSION IN THAILAND (BY +20%)



EFIGURE 4: PROJECTED OLDER ADULTS WITH HYPERTENSION AND DISABILITY IN THAILAND BY AGE GROUPS (BY -20%)



EFIGURE 5: PROJECTED TOTAL ANNUAL HEALTHCARE COST FOR COMMUNITY-DWELLING OLDER ADULTS WITH HYPERTENSION IN THAILAND (BY -20%)

