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Age effects on non-communicable diseases (NCDs) risk factors among Nepalese adult population

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Key Words

Non communicable diseases, risk factors, age effects, aging, health sector, NCDs

Abstract

Noncommunicable diseases are the leading cause of death and global public health challenges in 21st century. NCDs disproportionately affect people in LMICs, where more than three quarters of global NCDs deaths occur. Prevalence of common NCDs among elder population and estimated deaths attributed to NCDs are increasing in Nepal. Aging is inevitable and unavoidable but the growing NCDs burden among elders is creating a challenge for "healthy aging". Age effects on NCDs and their risk factors are yet to be explored in Nepalese context. Although NCDs among the elderly is a public health issue, it is not yet clear how to best manage NCDs at the primary healthcare level in Nepal.

In this cross-sectional study qualitative and quantitative approaches were used to examine the effects of age on behavioral and biological risk factors of NCDs and to evaluate how prepared the Nepalese health sector is for the prevention, early detection, and management of NCDs and their risk factors. Policy review, FGD and IDIs were used as qualitative methods, while statistical analysis for descriptive and prevalence estimates, and weighted multilevel regression were used for quantitative approach. The overall aim of the study was to examine the age effects on behavioral and biological risk factors of NCDs and to measure the readiness of the health sector for prevention and control of NCDs and their risk factors in Nepal.

Age and gender showed the strong aggravating effects on behavioral and biological risk factors. But, age interactions in the association between behavioral and biological risk factors were surprisingly weak. Insufficient policy commitment to address the increasing burden of NCDs and the mismatch between the design and execution of NCD prevention and control policies are the key findings of the qualitative analyses.

To prevent NCDs, risk factors need to be tackled early in life as there is strong effect of age on behavioral and behavioral risk factors. The limitation of the health sector readiness to respond the growing burden of NCDs and risk factors indicates an urgent need for reform.

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List of abbreviations

AOR:	Adjusted Odds Ratio
BMI:	Body Mass Index
COPD:	Chronic Obstructive Pulmonary Diseases
DALYs:	Disability Adjusted Life Years
FDG:	Focus Group Discussion
IDI:	In-depth Interview
LMICs:	Lower Middle-Income Countries
LMU:	Ludwig-Maximilians-Universität, Munich
MoHP:	Ministry of Health and Population
NCDs:	Non-Communicable Diseases(s)
NHRC:	Nepal Health Research Council
OR:	Odds Ratio
SDGs:	Sustainable Development Goal(s)
UHC:	Universal Health Coverage
WHO:	World Health Organization

List of publications

Paper A

Health sector readiness for the prevention and control of non-communicable diseases: A multi-method qualitative assessment in Nepal (DOI: 10.1371/journal.pone.0272361)

Paper B

Effects of age on non-communicable disease risk factors among Nepalese adults
(DOI: 10.1371/journal.pone.0281028)

1. My contribution to the publications

1.1 Contribution to paper A

I have invented the initial concept of the study and shared with the supervisors, after getting their feedbacks on the initial idea, I drafted the study protocol, finalized the techniques and tools for the study and execute the field work. With the guidance of PhD supervisors, I have completed the analysis of the qualitative data and derived the key results. The first draft manuscript has been drafted and shared with supervisors. Incorporating the feedbacks from the supervisors, the final draft manuscript has been prepared by me. While submitting the manuscript to the peer reviewed journal (PLoS ONE), I have contributed as corresponding author. I have responded to every comment by the reviewer and revised the manuscript based on their feedback.

1.2 Contribution to paper B

I have conceptualized the initial idea of the study and shared the research proposal with the PhD supervisors. Based on their feedbacks on study protocol, I have finalized the techniques and tools for the study. I performed the statistical analysis by using *r studio*. I have drafted the first draft manuscript and shared with PhD supervisors. I finalized the draft manuscript incorporating the feedbacks form the supervisors and made it ready to submit. During the submission process of the manuscript to the peer reviewed journal (PLoS ONE), my contribution was as corresponding author. I responded the comments made by the reviewer/editors and revised the manuscript as per their suggestion.

2. Introductory summary

2.1 Background

The growing pandemic of noncommunicable diseases (NCDs) is the leading cause of death worldwide, and one of the greatest health problems of the 21st century (1) (2). The main types of NCDs are cardiovascular diseases, cancers, chronic respiratory diseases and diabetes (3). Annually, 74% of global deaths (41 million deaths) are attributable to NCDs(4). Cardiovascular disease (CVD) is the number one killer (17.9 million deaths per year), followed by cancers (9.0 million deaths), respiratory disorders (3.9 million deaths) and diabetes (1.6 million deaths) worldwide (1). Due to the expensive health care cost and loss of the economically active age group by these four major killers, they are contributing significantly to the socio-economic and health impacts at present and in the future(5)

There is clear evidence that the four behavioral risk factors (tobacco use, harmful use of alcohol, unhealthy diets and physical inactivity) and the four biological risk factors (hyperglycemia, hyperlipidemia, hypertension and elevated BMI) contribute most to the development of NCDs(6). The prevalence of these behavioral and biological risk factors on NCDs burden remains unacceptably high and is still increasing(7).

Since the early days of 2020, world's attention has been focused on COVID-19 and its implication on health and economy, but COVID-19 is not the only global health emergency that exists now. Before the epidemic even started, the majority of global deaths were due to the NCDs. NCDs are also known to increase the risks from other infectious diseases and undermining people's health(8).

Over three quarters of all NCD fatalities (31.4 million) worldwide occur in lower and middle-income countries (LMICs), which are more heavily impacted by NCDs.–(3) (10). Eighty-five percent of all premature deaths caused by NCDs occur in LMICs(4)(9). In LMICs, more than 80% of fatalities from cardiovascular disease, diabetes, and nearly 90% of deaths from chronic obstructive pulmonary disease occur More than two thirds of all cancer deaths occur in LMICs where 7 out of 10 deaths are attributable to NCDs risk factors (10). By 2030, it is expected that in LMICs, NCDs would account for more than 50% of all fatalities.(11).

Like many other LMICs, in Nepal NCDs are emerging as a major cause of morbidity and mortality(12), (13). Estimated deaths attributed to NCDs increased from 51% in 2010 and 60% in 2014 to 66% in 2016 (14). World Health Organization (WHO) country profile of NCDs showed that the proportion of the major five risk factors is increasing over five years in Nepal (15) (16).

Moreover, the lack of appropriate treatment for NCDs and risk factors is one of the challenges for health system.

Table 1: Prevalence of common NCDs risk factors in Nepal

NCDs Risk Factors	Prevalence 2014	Prevalence 2018
Tobacco Use	30%	35%
Alcohol Consumption	2.2%	4%
Raised Blood Pressure	24.1%	27%
Obesity	1.4%	3%
Raised Blood Glucose	8.4	11%

Sources: WHO global status report of NCDs 2014 and 2018

NCDs contributed for just over a half (51%) of all deaths in Nepal in 2018(17). Data from various sources evidenced that nearly 12% of Nepal's adult population have Chronic Obstructive Pulmonary Diseases (COPDs) (18), 5% have cancer(19), 30% have hypertension (20), 8.4% have type 2 diabetes(21), 6% have Chronic Kidney Diseases(18), 21% are overweight or even obese(22), and 23% have raised cholesterol levels(22).

2.1.1 Role of Age on NCDs and risk factors

With age, the risk of NCDs and particularly the fatal incidences increase (23). All age groups, children, adults and the elderly are vulnerable to the risk factors contributing to NCDs(3)and accumulated throughout the life. Despite the fact that NCDs affect people of all ages, they are frequently linked to older age groups. (24). It was estimated that one person under the age of 70 dies due to the major NCDs in every two seconds (25). Global evidence suggests that every year 17 million NCDs deaths occur before the age of 70 years (24). Additionally, NCDs kill people at a younger age in LMICs, where 29% of NCD fatalities occur in adults under the age of 60, compared to 13% in high-income nations. (9).

In Nepal, risk factors associated with unhealthy behaviors (e.g. sedentary lifestyle and unhealthy nutrition) are increasing particularly among the younger generations. Biological risk factors (e.g. high BMI, high cholesterol and hypertension) are also getting more prevalent already among younger age groups. Due to the unmatched health care capability to tackle the needs of these health problems, there are increasing numbers of premature death in Nepal. Life expectancy has increased from 66.6 years in 2011 to 71 years in 2022, and 10.21 % of total population are elders. The proportion of elderly in the population is continuously in increasing (26). Prevalence of common

NCDs among elder population is higher compared to the general adult population in Nepal(27) and globally. That means the number and the proportion of people in the old age suffering by NCDs is increasing. These increasing numbers of people with NCD and NCD related illnesses are a big burden to the Nepalese health system. Treatment of NCDs and illnesses associated with NCDs is determining some economic implications at individual, family and community level. On top, it is also a big burden to the Nepalese economy, as people affected by NCDs and NCDs related illnesses are less productive.

Table 2: Prevalance of major NCDs among Nepalese adults and elderly

Four major NCDs	Prevalence (Among adults)	Prevalence (Among elders)
Coronary Artery Diseases	2.9%	4.4%
Diabetes Mellitus	8.5%	13%
Chronic Obstructive Pulmonary Diseases	11.7%	21.5%
Chronic Kidney Diseases	6%	11.5%

Source: Population based prevalence of selected NCDs in Nepal 2019

Aging is inevitable and unavoidable but the growing burden of NCDs among old aged population is creating a challenge health system and the economy to achieve the targets of "healthy aging"(28).

2.1.2 Impact of NCDs and risk factors on the health system

Most of the premature deaths from NCDs are preventable by treating the risk factors early enough, and by enabling health systems to respond to the health-care needs of people affected(29). Public health interventions targeting a healthier lifestyle, i.e. reducing tobacco use, unhealthy diet, harmful use of alcohol and physical inactivity, can prevent or delay significant ill health and a large number of deaths from many NCDs(30).

The deaths and severity of COVID-19 pandemic has been contributed significantly by NCDs(8). People living with NCDs when suffering from other infections, are often affected by higher complication rates. Disruptions in NCDs care due to the COVID pandemic was leading to excess mortality(31). The world can be better prepared for the next pandemic by enhancing the health systems to reduce the prevalence of NCDs across society. This points to the importance of investments in NCDs and risk factors in future pandemic preparedness and response strategies. The COVID-19 recovery provides the world with an opportunity to built back better and enhance health security which is not complete without considering the NCDs as an integral part(8).

Investment in NCDs not only would bring the improvements in health outcomes, it would also improve financial and social wellbeing, improve resilience to other infectious diseases(30). Tackling NCDs is not just about to reach the target, it is an opportunity for government to unlock the many benefits of a healthier, happier and more productive society and to benefit the sustainable development goals (30).

In LMICs, governments are struggling to find a solution for the increasing health and financial implications of the NCDs pandemics(32). The need of an innovative, all-encompassing, and potentially cost-effective strategy to the prevention and management of NCDs is indicated by the rising trend of NCDs and risk factors. (33).

2.2 Statement of the problem

As governments strive to achieve the targets of Sustainable Development Goals (SDGs) (34)and efforts toward universal health coverage (UHC)(35) but the rising NCDs pandemic is creating the significant barriers to these aspirations(36). Only a few nations are on pace to achieve SDG 3.4, which is to reduce NCD-related early deaths. But with the correct investments and initiatives via a robust health system, 90% of LMICs may still reach SDG 3.4 by 2030. (30). Despite the destructive long impact of NCDs on society, economy and health, NCDs prevention and control has received relatively lower priority and too little investment in many LMICs. The additional impact of COVID-19 has left more people at higher risk of dying, being undiagnosed, untreated, and unprotected(8).

In spite of this growing need for long-term chronic disease care, historically, Nepalese healthcare system has been designed focusing on delivering acute, episodic care, lacking the capacity to provide sufficient care and support to respond the need of people suffering by NCDs(37). Wide disparity in access to health services and increased out-of-pocket expenditure to health care is increasing in LMICs(38), with Nepal being no exception.

NCDs are a significant public health issue in Nepal, but it is unclear how to best address them at the basic healthcare level. (39). In order to develop and implement evidence-based policies, strategies, and programs for the prevention and management of NCDs in older populations, age effects on NCDs and associated risk factors must still be investigated in the Nepalese context..

Existing literature suggests a higher prevalence of NCDs and their risk factors among the older population, but the effect of age on the NCDs and their risk factors has not received much attention

in Nepalese health sector. This work has been conducted combining the qualitative and quantitative techniques. The study assesses the health sector readiness for prevention and control of NCDs and their risk factors analysing the plans, policies and programs designed and executed and interacting with the health service providers, policy makers and program managers in Nepalese health system. In addition, the study has explored the age effects on NCDs and their risk factors among Nepalese adults.

2.3 Objectives

The aim of the study is to assess the readiness of the Nepalese health sector for prevention and control of NCDs and their risk factors and to investigate the age effects on behavioral and biological risk factors of NCDs among Nepalese adults. Followings are the specific objectives of the study categorized as the two different components.

2.3.1 Objectives for qualitative component of the study

- To explore the perspectives and the perception of policy makers, program managers and service providers on preparedness and response of health sector for NCDs and risk factors including age.
- To evaluate the Nepalese health sector's readiness for the prevention, management, and control of NCDs and their risk factors including age.

2.3.2 Objectives for quantitative component of the study

- To assess the variation of behavioral and biological risk factors in different age groups.
- To investigate how age is modifying the effects of health behavior on biological risk factors.

2.4 Methods

The study is based on a cross-sectional study design with both the qualitative and quantitative approaches. The Qualitative component was performed in first phase and followed by the quantitative component in a second phase.

2.4.1 Methods used in qualitative analysis

*(**Paper A**: **"**Health sector readiness for the prevention and control of non-communicable diseases: A multi-method qualitative assessment in Nepal")*

For the qualitative approach field work has been conducted to collect the qualitative data as primary source. Policy review, FGDs and IDIs were used as qualitative methods to assess the health sector readiness for prevention and control of NCDs and risk factors.

The qualitative methods of the study have explored the readiness of the Nepalese health sector through the perspectives of policy makers, program managers and service providers. Contents review of policy documents, focus group discussion (FGD) with health service providers and in-depth interview (IDI) with policy makers and program managers have been adopted as qualitative approach. Primary information collected through the fieldwork has been analyzed based on the six-health system building blocks: health services, human resources, health information, health commodities, finance, governance and leadership. Thematic content analysis was performed to abstract the qualitative findings across the six-health system building blocks.

2.4.2 Methods used in quantitative analysis

***(Paper B:** "Effects of age on non-communicable disease risk factors among Nepalese adults")*

For the quantitative approach, further analysis of data from STEPS survey-2019 was used as secondary source. Descriptive and prevalence estimates, and weighted multilevel regression were used to assess the effects of age on NCDs risk factors.

The quantitative methods of the study have focused on investigating the age effects on non-communicable diseases risk factors among Nepalese adults by using the data of STEPS survey-2019. This survey contains a nationwide representative sample of 5593 participants from a population-based household survey of adults aged 15-69 years. Multistage cluster sampling was used as sampling technique. From each of the seven provinces, 37 community clusters were randomly selected resulting in 259 primary sampling units (PSU). Subsequently 25 randomly selected households from each PSU were included in the study and one adult per household was enrolled in the study.

Statistical analyses were conducted using the statistical software R, version R 4.1.1. Analysis used inverse probability weighting based on the sampling probabilities to adjust for differences in the age and sex composition of the sample population.

The prevalence of behavioral and biological risk factors was estimated by weighted frequencies. To investigate the magnitude and pattern of the NCD risk factors by age, differences in prevalence estimates are stratified by three age groups: "15-35 years", "35-59 years" and "60 years and above".

Weighted multilevel logistic regression for clustered survey data was used to assess the association of sociodemographic characteristics with behavioral risk factors and the association of behavioral risk factors with biological risk factors. Age effects were analyzed by including age in all models as a categorical variable. Regression models were fitted with and without adjustment for sociodemographic variables.

2.4.3 Conceptual framework of study

The study has been conducted by blending the different techniques of qualitative and quantitative approaches. The underlying conceptual framework of the study is given in figure 1. In the quantitative component, socio-demographic determinants, behavioral risk factors and biological risk factors have been analyzed. The age effects in the association shown by colored and solid arrows (as illustrated in figure 1) have been analyzed.

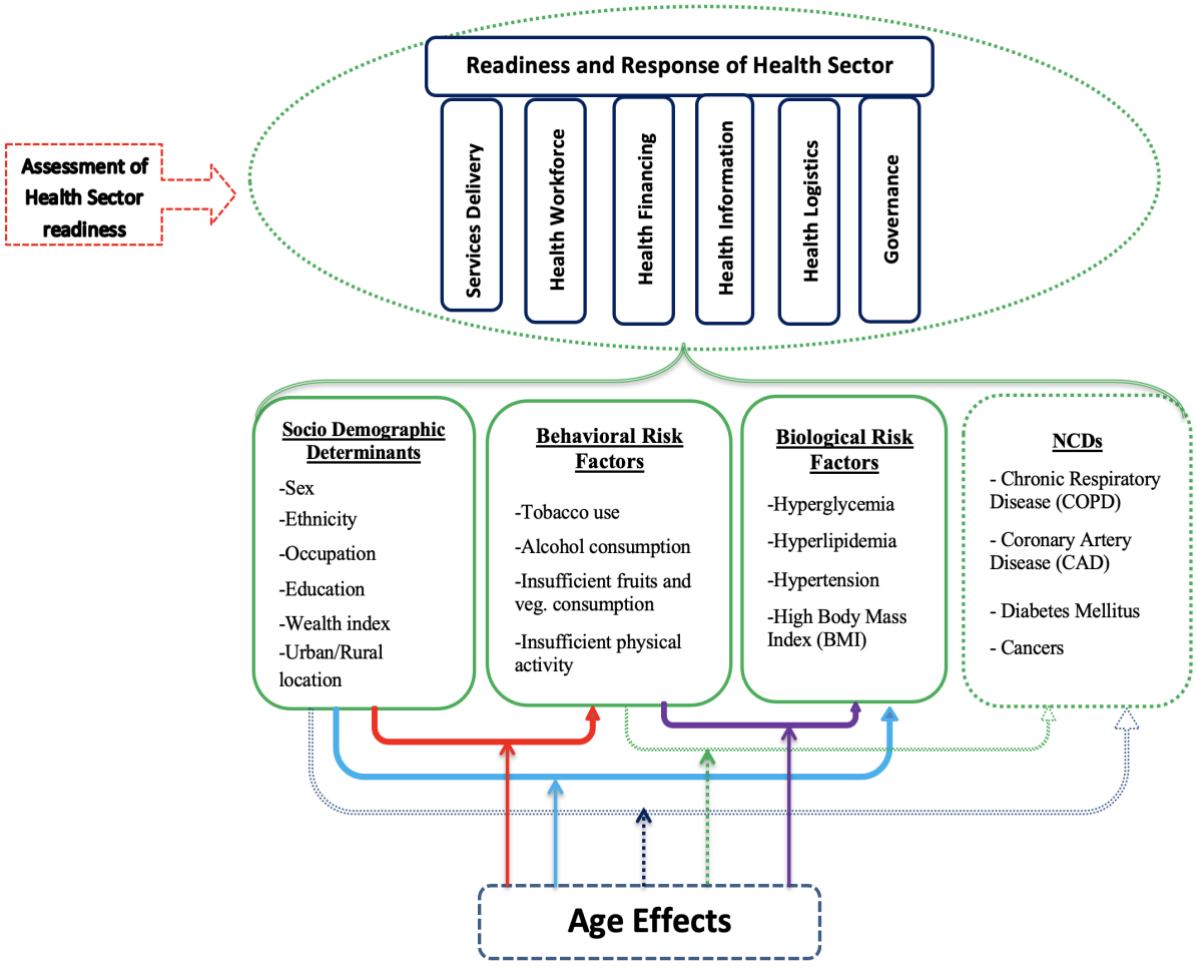

Figure 1: Conceptual framework of the study

2.4.4 Ethical considerations

Permission to conduct the qualitative study (policy review, FGDs and IDIs with government employees) was obtained from the Ministry of Health and Population (reference no. 384 dated 2 April, 2020). Administrative permission to use the data of 'STEPS survey 2019' for this study was obtained from the Nepal Health Research Council (NHRC) via the letter (reference no. 786). Ethical approval for the study was granted by the ethical review board of NHRC (reference no. 2882 dated 14 July 2020) and from the ethical committee of the Munich Medical Research School, LMU Munich, Germany (project no. Hb/mbg: 20-657 dated 21.08.2020).

2.5 Results

The study comprises both the qualitative and quantitative components. Qualitative techniques have been used to explore the perspectives and perception about the health sector readiness for prevention and control of NCDs and their risk factors among the policy makers, program managers and health workers. Among the 182 identified policy documents twenty-eight were included for content analysis. There were 49 participants participated across eight FGDs along with 1 respondent for 11 IDIs each.

Quantitative approach has been adopted to examine the age effects on behavioral and biological risk factors of NCDs among Nepalese adults. Statistical analysis of the data from STEPS survey - 2019 comprising nationally representative samples of 5593 adults has been conducted. The results of the study have been summarized as below.

2.5.1 Results from qualitative study

Health sector policy documents reviewed in the study were found to be aware about the growing burden of NCDs, but are almost silent about the need to address risk factor for NCDs. Existing policy are focused towards the curative services but preventive and promotive interventions are almost neglected. FGDs and IDIs revealed that poor retention of trained health workers represents the common health problem in local, provincial and federal level health facilities. Because more than half of the sanctioned posts in healthcare institutions remained unfilled, the workload at all levels of healthcare increased. Inadequate amounts and standards of drugs, equipment and instruments are the key logistics issue. Budget allocation targeting the NCDs intervention was inadequate. Generation and use of available evidences during design and execution of NCDs program interventions was not in practice. Nonhealth sectors engagement for the prevention and control of NCDs was largely lacking.

In summary, the key finding of this study is insufficient policy commitments to respond to the growing burden of NCDs. There is a gap between the design and implementation of policy into practice forprevention and control of NCDs in Nepal. Moreover, there is a significant weakness apparent in each of the six-health system building blocks.

2.5.2 Results from quantitative study

The prevalence of behavioral risk factors for NCDs, smoking, alcohol consumption and insufficient physical activity, increase with age. Similarly, the prevalence of the biological risk factors hypertension and hyperlipidemia significantly increase with age.

Among the oldest population, 60 years and above, hypertension affects every third man and more than one in five women. Moreover, more than a third of elderly women suffer from hyperlipidemia.

Diabetes as well as overweight and obesity are more prevalent among the middle-aged population, 35-59 years of age. In this population group, every third person is overweight or obese and more than 8% suffer from diabetes. Such finding might have some indication of a generation effect.

Our study has revealed that 'age' is the most important factor influencing the prevalence of behavioral and biological risk factors for NCDs. But age interactions in the association between behavioral and biological risk factors are significantly weak. Among four behavioral risk factors, only alcohol consumption in women showed a significant impact on the biological risk factors hypertension, hyperlipidemia and overweight and obesity. The diagnosis of and treatment for the biological risks factors is very low among Nepalese adults.

2.6 Discussion

Based on policy papers, the perspectives of health professionals, and health decision makers, the preparedness of the health sector with regard to the prevention and control of NCDs and risk factors has been studied. Growing burden of NCDs has been reflected in the policy documents and perceptions of policy makers, but they were less sensitive towards the need to address risk factors.

The findings of our study revealed that the health sector readiness for prevention and control of NCDs and risk factors is not sufficient, which is identical with findings from similar studies in Asia (India and Thailand) and Africa (Zambia and Ghana). Qualitative assessment of health system preparedness in India (40) and Thailand (41) identified a low level of preparedness for NCD prevention and control. Lower level of preparedness for major NCDs have also been commonly reported in Zambia (42)and Ghana(43).

The increasing proportion of aging population and growing burden of NCDs demands intervention to prevent and control NCDs with particular attention to the growing elderly population in Nepal (44). But neither the policy documents reviewed nor the policy makers interviewed explicitly mentioned health needs of elders, neither in the context of NCDs and risk factors nor to meet the targets of healthy ageing(45).

While exploring the effects of age on behavioral and behavioral risk factors, it is observed that NCDs and risk factors are increasing with growing ages. Moreover, there are cumulative effects of NCDs risk factors since early stage of life. These study findings are similar to the findings from the previous studies in LMICs (46,47). The finding of our study is showing that behavioral risk factors are more prevalent among men, while biological risks factors, specifically overweight, obesity and hyperlipidemia, are more common among women. This finding is similar to the previous studies among adults from eleven European countries (48). Our study suggested that in Nepal the risk of hyperlipidemia increases with age but not with smoking, in contrast to European countries, for which a study has shown that hyperlipidemia is more common among smokers(49).

The effect of alcohol consumption in three different age groups suggests that the chance of hypertension among women is significantly increased by alcohol consumption. The association between alcohol consumption and hypertension among the older age group is not significant, where the effect is leveled out by the interaction effect with age.

The association between behavioral and biological risk factor is complex, which is being more complicated by the age effects on NCDs and their risk factors. With an increasing life expectancy, a growing elderly population has further exacerbate the health problem due to NCDs and this must be taken into account in design and execution of the health sector response to NCDs. There is a dire need for a policy and program reform to redirect health sector priorities with regards to the age effects on NCDs and risk factors as well as prevention and control of NCD risk factors.

2.7 Conclusion

Age and sex have the strongest effect on behavioral and biological risk factors and ultimately on the prevalence of NCDs. To prevent NCDs, risk factors of NCDs need to be tackled early in life, through both, awareness and creating conducive physical, social and policy environments that allow people to pursue a healthy-behavior throughout life. Notably, ensuring a healthy diet for the younger generation will help to prevent overweight and obesity in the next generations.

Age effects on NCDs risk factors is demanding the need of serious considerations to prevent NCDs among a growing elderly population while preparing and executing the health sector response to NCDs. There is alarming limitation of the health sector readiness to respond the growing burden of NCDs, indicating the immediate reform. Critical gaps have been observed in the design and execution of the NCDs targeted policies and programs in all the six building blocks (service delivery, human resources, health commodities, finance, information management, governance and leadership) of health system.

2.8 Outlook

The study revealed the crucial evidences which will be useful for the policy decisions and program design targeting the prevention and control of NCDs in Nepalese health sector.

The qualitative component of this study has revealed the need of conducive physical, social and policy environments in Nepalese health sector for its better preparedness to prevent and control the NCDs and risk factors. Moreover, lack of facilities for early diagnosis and appropriate treatment of NCDs and the limited general health care capabilities for communities in difficult terrain and rural location have been identified as some of the health sector's risk factors. A health system research based on more robust study designs would explore how to address the health system risk factors in Nepalese health sector.

The quantitative component of our study has explored the age effects on behavioral and biological risk factors of NCDs. Age has been identified as an unavoidable but significantly influencing risk factor and influencing all the risk factors of NCDs. The study findings gave us the stimuli to further dig down the effects of age on common NCDs and we are working on it by using a cross-sectional data source in Nepal. Based on the study findings, we recommend the public health interventions to promote the healthy behaviors and physical activities targeting the younger aged people since early stage of life.

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4. Publications

4.1 Paper A

Health sector readiness for the prevention and control of non-communicable diseases: A multi-method qualitative assessment in Nepal *(DOI: 10.1371/journal.pone.0272361)*

PLOS ONE

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Health sector readiness for the prevention and control of non-communicable diseases: A multi-method qualitative assessment in Nepal

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Abstract

In Nepal, deaths attributable to NCDs have increased in recent years. Although NCDs constitute a major public health problem, how best to address this has not received much attention. The objective of this study was to assess the readiness of the Nepalese health sector for the prevention and control of NCDs and their risk factors. The study followed a multimethod qualitative approach, using a review of policy documents, focus group discussions (FGDs), and in-depth interviews (IDIs) conducted between August and December 2020. The policy review was performed across four policy categories. FGDs were undertaken with different cadres of health workers and IDIs with policy makers, program managers and service providers. We performed content analysis using the WHO health system building blocks framework as the main categories. Policy documents were concerned with the growing NCD burden, but neglect the control of risk factors. FGDs and IDIs reveal significant perceived weaknesses in each of the six building blocks. According to study participants, existing services were focused on curative rather than preventive interventions. Poor retention of all health workers in rural locations, and of skilled health workers in urban locations led to the health workers across all levels being overburdened. Inadequate quantity and quality of health commodities for NCDs emerged as an important logistics issue. Monitoring and reporting for NCDs and their risk factors was found to be largely absent. Program decisions regarding NCDs did not use the available evidence. The limited budget dedicated to NCDs is being allocated to curative services. The engagement of non-health sectors with the prevention and control of NCDs remained largely neglected. There is a need to redirect health sector priorities towards NCD risk factors, notably to promote healthy diets and physical activity and to limit tobacco and alcohol consumption, at policy as well as community levels.

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Introduction

The global burden of non-communicable diseases (NCDs) constitutes a major public health challenge as well as a serious threat to social and economic development now and in the future [1]. The growing pandemic of NCDs is mainly caused by cardiovascular diseases, cancers, chronic respiratory diseases and diabetes [1, 2]. These four major killers contribute to more deaths globally than all other diseases combined [3]. The proportion of global deaths due to NCDs has increased from 68% in 2012 to 71% in 2016 [4]. NCDs account for 50% of all disabilities worldwide [5].

Low- and middle-income countries (LMICs) are being affected disproportionately, as they are home to around 80% of global NCD deaths and around 90% of early preventable NCD deaths [5]. NCDs as a share of total deaths are projected to increase by more than 50% in LMICs by 2030 [5]. Nepal has higher age-standardized death rates and disability-adjusted life years due to NCDs compared to communicable diseases [6]. The estimated contribution of NCD-attributable deaths has been increasing in Nepal: from 51% in 2010 and 60% in 2014 to 66% in 2016 [7]. Life expectancy at birth has been projected to increase from 67 years in 2011 to 71 years in 2019 [8], with the proportion of the elderly population (i.e. those aged 80 and older) increasing in parallel [8]. Aging is inevitable and unavoidable but the growing burden of NCDs among the elderly population is creating a challenge for "healthy aging" [9].

The major NCDs share common behavioral (i.e. tobacco, unhealthy diet, physical inactivity and the harmful use of alcohol) and biological risk factors (i.e. hypertension, hyperglycemia, hyperlipidemia and obesity) pointing to key pathways for prevention [10]. Several high-level commitments have recognized the preventability of NCDs and the urgent need for action to control them [11, 12]. The WHO Global NCD Action Plan with its nine targets for the prevention and control of NCDs and risk factors emphasizes national actions in the context of international cooperation and solidarity [1]. Based on cost effectiveness analysis, there are ten 'best buys' to address four major NCDs and their risk factors [13, 14].

Although NCDs constitute a major public health problem in Nepal, how best to address NCDs in primary health care and across different levels of the health system is not well described [4]. As a member state of the World Health Organization (WHO), Nepal is committed to achieving the targets of the 25x25 strategy of WHO, i.e. a relative reduction of premature deaths due to NCDs by 25% by 2025 [1]. As a UN member state, Nepal is also committed to achieving SDG target 3.4., i.e. a one third reduction of the premature mortality due to NCDs [15]. Nepal has initiated efforts to prevent and control NCDs through the ratification of a national policy in 2009, and through a strategy and plan of action in 2014 [16]. Readiness refers to the extent of willingness and ability of an organization to implement a particular intervention [17]. Health sector readiness is understood as the preparedness of health institutions to accept the challenges brought about by new health problems [18]. How the health sector has been preparing and responding to the growing pandemic of NCDs and its underlying risk factors has yet to be understood [19].

The aim of this study was to assess the readiness of the Nepalese health sector with regards to the prevention and control of NCDs and their risk factors by exploring the perspectives of policy makers, program managers and service providers. The study sought understand how NCD prevention and control in anchored in Nepalese policy documents and how different cadres of health workers as well as health policy makers and program managers at provincial and local levels perceive health sector readiness with regards to NCDs prevention and control .

Materials and methods

Study setting

Following the re-organization of the government health sector in the year 2015, the Nepalese health sector is characterized by three tiers of governance at federal, provincial and local levels. This study tried to capture insights across all three levels of the health system: document analysis was primarily concerned with the federal level, whereas qualitative research was carried out in three provinces– Bagmati, Gandaki and Karnali–which best represent the eco-political variations within Nepal. Within the three provinces, districts were purposively selected to cover the three distinct ecological regions of Nepal, i.e. mountains, hills and terai (plain). Kathmandu, Sindhupalchok and Chitwan district from Bagmati province, Kaski and Nawalpur districts from Gandaki province and Dailekh and Surkhet district from Karnali province were included in the study.

Study design and participants: The study adopted a multi-method qualitative approach, using a review of policy documents, focus group discussions (FGDs) and in-depth interviews (IDIs).

Review of policy documents: A wide range of policy decisions adopted by the Government of Nepal (GoN) were considered as "policy documents", notably the Nepalese constitution and various acts, regulations, policies, periodic plans, annual plans, strategies, guidelines, protocols and commission reports.

To identify policy documents, the official websites of the Ministry of Health and Population (MoHP, www.mohp.gov.np) and the Department of Health Services (DoHS, www.dohs.gov. np) were searched during the period August to September 2020. Any NCD- and NCD risk factor-related documents containing one of the following terms were considered for inclusion: 'policy', 'act', 'regulation', 'report', 'plan', 'program', 'strategy','guideline', 'protocol', 'package' and 'report'.

In addition, direct interactions with the policy section chief enabled access to a collection of policy documents at the MoHP. After de-duplication of records identified, a two-stage screening process was undertaken, initially screening for overall thematic relevance and subsequently screening for a matching of explicit terms related to 'NCDs' or their 'risk factors' in the contents (Fig 1).

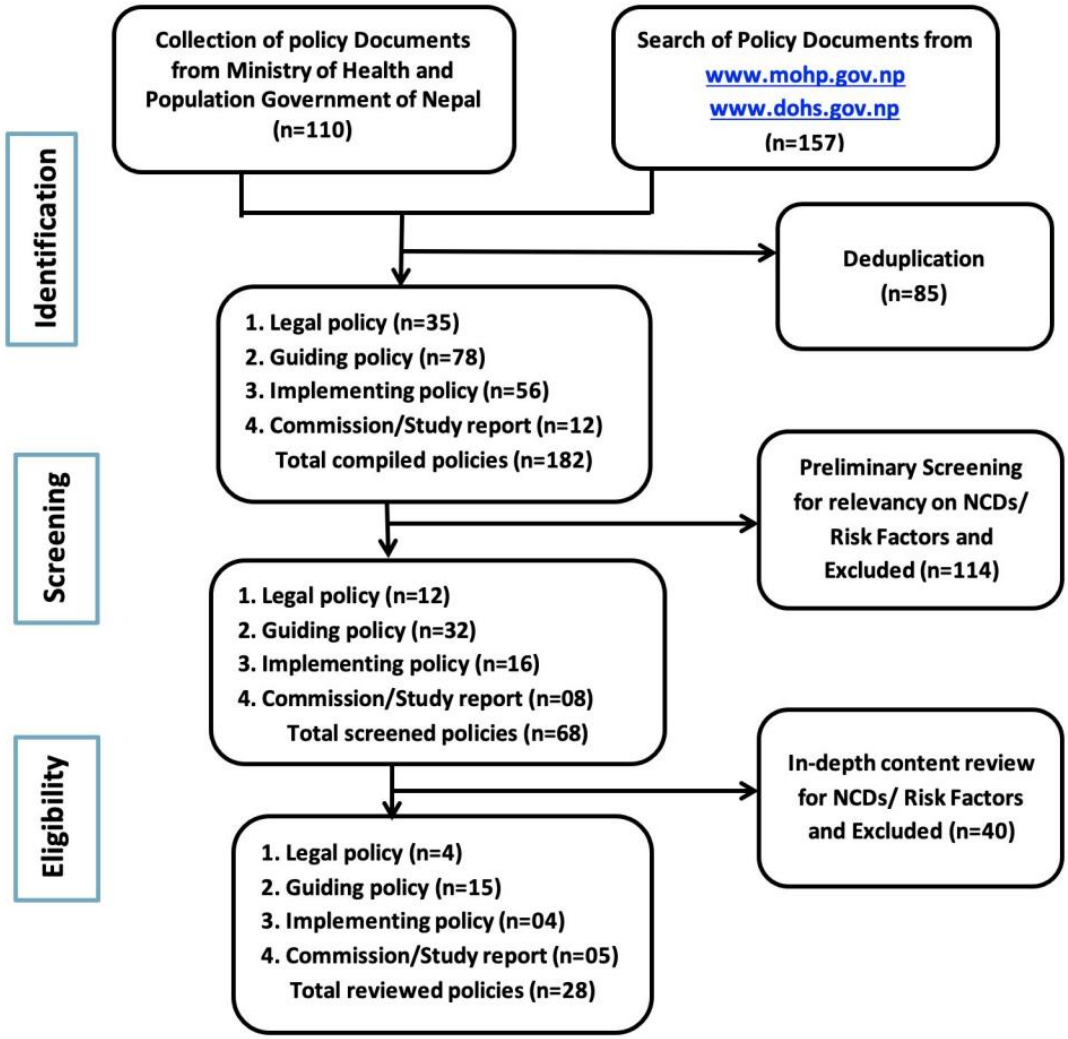

Fig 1. Strategy for screening policy documents.

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Based on their title and/or contents, the shortlisted policy documents were categorised into four broad groups: legal policies, guiding policies, implementing policies and commission/ study reports. Content analysis was performed within each category. To do so, the policy documents were read and reviewed throughly for the purpose of content familiarization. Subsequently, explicit statements mentioned in the policy documents about the prevention and control of NCDs and/or their risk factors were extracted onto a data extraction form. Qualitative information was organised using a deductive

approach, sorting information according to the WHO health system building blocks framework, i.e. as health service delivery,health work force, health logistics, health financing, health information and surveillance, governance and leadership [20, 21].

FGDs and IDIs: FGDs were conducted with different cadres of health workers working in health posts (HPs), primary healthcare centers (PHCs), the municipality health section, municipal hospitals and provincial hospitals. IDIs were undertaken with policy makers, program managers and service providers in a complementary manner. FGD and IDI participants were selected purposively with a view to identifying multiple perspectives across different levels (i.e. provincial and local) and tasks of the health system and to ensure maximum variation.

A semi-structured FGD guide and a semi-structured IDI guide were designed based on the six health system building blocks. Pilot testing for the FGD guide was conducted with health workers at a primary healthcare center in Lalitpur. Pilot testing for the IDI guide was conducted with a mayor from Godavari municipality in Lalitpur. FGDs and IDIs took place between October and December 2020. They were moderated by an experienced researcher (BPS) and supported by a research assistant trained on how to conduct FGDs and IDIs who took notes. All discussions and interviews were audio-recorded. At the beginning participants were introduced to the objectives of the study, and written informed consent for their voluntary participation and audio recording was obtained. All FGDs and IDIs were conducted faceto-face in a convenient location at the participants' work place just after working hours. In doing so during the COVID-19 pandemic, appropriate public health measures were adopted and included physical distancing, the use of face mask and the use of sanitizer.

Audio recordings of the FGDs and IDIs were transcribed verbatim by the moderator (BPS) within 24 hours of the discussion or interview. The transcript was translated from Nepali to English by a bi-lingual expert and subsequently checked for accuracy of the translation by the moderator (BPS).

The transcripts were then analyzed manually using qualitative content analysis [22, 23]. The texts were reviewed iteratively and an initial set of codes was developed in an inductive manner. Codes were generated using the transcripts of the first two FGDs and IDIs; these were subsequently applied to the remaining FGDs and IDIs. From these codes themes were developed inductively and organized according to the six building blocks of the health system.

Initially, findings from the first FGDs and IDIs were compared with a view to examining differences between local and provincial levels; then, the same approach was applied to all FGDs and IDIs. In

analyzing findings, we also specifically examined any reference made to the elderly population. Initial stages of the analysis (i.e. coding) were undertaken by a single researcher(BPS), subsequently, all authors engaged with the analysis and interpretation of data.

Ethical approval

Ethical approval for the study was obtained from the ethical review board of the Nepal Health Research Council by reference letter no. 2882 dated 14 July 2020, and from the ethical committee of the Munich Medical Research School, LMU Munich, Germany by a letter dated 21.08.2020 (Hb/mbg, project no.20-657). Administrative permission to conduct FGDs and IDIs with government employees was obtained from the MoHP.

Inclusivity in global research: The ethical, cultural and scientific considerations specific to inclusivity in global research has been fully maintained.

Authors positionality

BPS is a male public health professional in Kathmandu, Nepal, and has spent almost two decades working in various functions in the Nepalese health sector. Both as a Ministry of Health employee and as a PhD student at the LMU Munich, where he further enhances his quantitative as well as qualitative research skills, he seeks to draw attention to the rising burden of non-communicable diseases in his home country, which may have influenced his interpretation of the data towards a need for action.

KPB is a male academic in Lalitpur, Nepal, having spent almost two decades in health system research and community health at national and sub-national levels.

UB is a female statistician and senior scientist at LMU Munich, new to qualitative research, but with long-standing expertise in quantitative research projects across a range of health topics, primarily in Europe but also in Africa and Asia.

KGP is a male professor of endocrinology and metabolism at the University hospital of LMU Munich, with a clinical and scientific focus on NCDs, notably obesity, diabetes and lipid disorders. His NCD-focused research has taken place in Germany, Europe and the USA, as well as in different Asian and African countries.

ER is a professor of public health and health services research at the LMU Munich, with a research focus on evidence-based public health and a strong command of a range of quantitative and

qualitative research methods. A German female, she spent many years working for the World Health Organization and has been coordinating large research projects in sub-Saharan Africa; she has supervised several Nepalese PhD students, traveling the country and obtaining insights into how the Nepalese health system works. She firmly believes in the need to step up primary prevention and to address root causes of disease, a perspective that has sensitized her to focus on risk factors for disease.

Findings

Of 182 unique policy documents identified, twenty-eight were included for content analysis, comprising four legal policies, 15 guiding policies, four implementing policies and five commission/study reports (Table 1).

We included 49 participants across eight FGDs and conducted 11 IDIs. None of the participants refused to participate and none dropped out. The average time taken for FGDs was 60 minutes (range: 50–70 minutes) while the average time taken for IDIs was 53 minutes (range: 45–90 minutes). Characteristics of the FGDs are shown in Table 2, characteristics of the IDIs are presented in Table 3.

Table 1. List of policy documents.

Types of policy documents	Name of policy documents
Legal policies	1. Constitution of Nepal 2016 2. Public Health Service Act-2018/Regulation 2019 3. Nepal Health Insurance Board Act 2015 4. Tobacco Products (control and regulatory) Act 2011/regulation-2012
Guiding policies	1. National Health Policy 2019 2. 15th Periodic Plan 2020–2024 3. 14th Periodic Plan 2017–2019 4. 13th periodic Plan 2014–2016 5. Nepal Health Sector Strategy 2015–2020 6. Integrated policy for prevention and control of NCDs 2006 7. NCDs Multi sectoral Action Plan 2014–2020 8. Urban Health Policy 2006 9. National Nutrition Policy and Strategy 2008 10. Multi sectoral Nutrition Plan 2018–2022 11. School Health and Nutrition Strategy 2006 12. National Population Policy 2015 13. National Policy on control and regulation of Alcohol 2017 14. Tobacco Control Strategy 2018 15. Nepal Health Sector Strategy Implementation Plan 2016–2021
Implementing policies	1. Guideline for Package of Essential NCDs training 2018 2. Guideline for the Poor Citizen Treatment Fund 2006 3. National Development Program 2020 4. Basic Health Service Package 2018

Commision/study reports	1. Assessment Report of NCD Multi-Sectoral Action Plan (2014–2020)-2019 2. The Nepal NCDI Poverty Commission National Report 2018 3. National Report on SDG Progress 2016–2030 4. Policy research on health-related SDGs in Nepal 2017 5. National Burden of Disease 2017

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Table 2. Characteristics of FGDs participants.

FGD No.	Categories of participants	Governing level	Province	Type of health facilities	Duration	Date	Number of participants	Eco-regional representation
FGD 1	Health workers (Doctor, Paramedic, Nurses, Lab tech)	Local government	Bagmati province	Primary health center	60 minutes	9 October, 2020	7 (3 Male, 4 Female)	Rural mountain
FGD 2	Health workers (Nurses, Paramedics, Lab technician)	Local government	Gandaki province	Municipal hospital	50 minutes	12 October, 2020	6 (3 Male, 3 Female)	Urban hill
FGD 3	Doctors (Internist, Dental surgeon, Physician, Medical Officers)	Provincial government	Bagmati province	Provincial hospital	55 minutes	21 October, 2020	6 (4 Male, 2 Female)	Urban terai
FGD 4	Health coordinators at municipality	Local government	Gandaki and Bagmati	Municipal level authorities	70 minutes	24 October, 2020	7 (7 Male, 0 Female)	Rural hill and terai (mixed group)
FGD 5	Health posts in-charges in different HPs	Local government	Bagmati province	Local level health posts	65 minutes	28 October, 2020	5 (2 Male, 3 Female)	Urban hill
FGD 6	Health woHP:(Nurses, Paramedics, Lab tech)	Local government	Bagmati province	Local level health post	55 minutes	3 November, 2020	5 (3 Male, 2 Female)	Urban terai
FGD 7	Doctors (Medical officers, Dentist, Gynecologists, Medical Generalist)	Provincial government	Karnali province	Provincial hospital	60 minutes	20 December, 2020	7 (3 Male, 4 Female)	Urban mountain
FGD 8	Health workers at health posts (Nurses, Paramedics, Lab tech)	Local government	Karnali province	Local level health post	65 minutes	23 December, 2020	6 (2 Male, 4 Female)	Rural hill

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Table 3. Characteristics of IDIs participants.

No. of IDI	Governing level (province)	Interview setting/province	Type of responsibility	Duration of interview	Date	Gender of interviewe	Total experience (exp. of current position)
IDI No. 1	Local Government (Bagmati)	Municipal office, Bagmati	Program manager	45 Minutes	9 October, 2020	Male	15 yrs. (1 yrs.)
IDI No. 2	Provincial Government (Gandaki)	Ministry of Social Development, Gandaki	Policy maker	60 Minutes	12 October, 2020	Male	15 yrs. (1.5 yrs.)
IDI No.3	Provincial Government (Gandaki)	Province Health Training Center, Gandaki	Program manager	45 Minutes	13 October, 2020	Male	15 yrs. (2yrs.)
IDI No.4	Federal Government	Policy and Planning Section, MoHP	Policy maker	45 Minutes	16 October, 2020	Male	20 yrs. (2yrs.)

IDI No.5	Province Government (Bagmati)	District Health Office, Bagmati	Program manager	45 Minutes	21 October, 2020	Male	8 yrs. (1 yr.)
IDI No. 6	Local Government	Metropolitan city, Bagmati	Policy maker	45 Minutes	22 October, 2020	Male	15 yrs. (1 yrs.)
IDI No.7	Local level (Gandaki)	Municipal Hospital, Gandaki	Service provider	45 Minutes	3 November, 2020	Male	4 yrs. (1 yrs.)
IDI No.8	Province Government (Karnali)	District Health Office, Karnali	Program manager	90 Minutes	21 December, 2020	Male	5 yrs. (1 yrs.)
IDI No.9	Province Government (Karnali)	Provincial Health Directorate, Karnali	Policy maker	60 Minutes	22 December,2020	Male	10 Yrs. (6 Months)
IDI No.10	Local Government (Karnali)	Municipality Office, Karnali	Program manager	60 Minutes	23 December,2020	Male	10 yrs. (2yrs.)
IDI No.11	Local Government (Karnali)	Health Post, Karnali	Service provider	45 Minutes	23 December,2020	Male	5 yrs. (2 yrs.)

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The insights gained from the review of policy documents and from the FGDs and IDIs are presented in an integrated manner for each of the six health system building blocks, exploring similarities and differences between provincial and local levels. The findings are reported as per the consolidated criteria for reporting qualitative research (COREQ) guidance [24].

Health service delivery

Health service delivery was explicitly mentioned in the majority of policy documents, notably in three legal policies, four implementing policies, thirteen guiding policies, and four commission/study reports but this was focused on curative services. Preventive and health promotive services were mentioned only in a limited number of documents. The quality of health services regarding NCDs was suggested to be an additional problem.

"*...despite the increased burden of NCDs due to globalization and life style change, there is a lack of quality and uniformity in health services...*" *-15th Periodic plan,2019–2024*

Multi-sectoral engagement for NCD services with a view to tackling NCD risk factors was addressed in most of the policy documents. Notably, the National Health Policy 2015 specifies the need for integrated health services for the prevention and control of NCDs and their risk factors. Among the four behavioral risk factors of interest, interventions for tobacco control received the greatest policy attention, putting alcohol control in second place. Policy documents rarely referred to unhealthy foods

or physical inactivity. Health services to meet the needs of the elderly population were not mentioned in any of the policy documents.

Most FGD participants and IDIs commented on the limited availability of NCD-specific health services, but some differences emerged with regards to the perception of these services at provincial and local levels. FGD participants at the local level emphasised that any available services for NCDs were part of basic health services. Similar opinions were found during an IDI with a provincial policy maker from Karnali province who had indicated the lack of NCDspecific curative services as well as services targeting NCDs risk factors. Municipal FGD participants highlighted that the package for essential NCD services (PEN) was available at the primary health care level. Provincial FGD participants reported that NCD services had been initiated in all three provinces; their effective implementation was only reported by FGD participants from Karnali province.

"*...there are no specific services targeting non-communicable diseases; medical consultation, free drugs, laboratory services and periodic health camps are a part of basic health services...*"

- FGD in Bagmati Province

A notable difference emerged for Bagmati province, where FGD participants described a community-based screening program targeting diabetes and hypertension. The program manager in Bagmati province also stressed the value of the initiatives of the school nurse program with regards to health promotion services. The program manager in Karnali province also provided some good examples of NCD-targeted services, e.g. cervical cancer screening and cash support for referral services. Health services targeting the health needs of the elderly population were not mentioned by any of the policy makers, program managers and health service providers across the three tiers of health system governance.

Health workforce

Three guiding policies, two implementing policies and one commission/study report explicitly stressed the importance of the health workforce in the prevention and control of NCDs. These policy documents emphasize the training and skills of all cadres of health workers as well as the critical role played by community health workers for preventive and promotive interventions. They point to the critical scarcity of the health workforce in rural locations and the insufficient number of health workers trained on NCDs in urban locations. None of the policy documents identified the need for 'NCD service providers' as a new category of health workers. Despite the policy provision for the

production of a service-oriented clinical workforce in the 15th periodic plan, none of the policy documents define quantitative targets for the training, recruitment, and retention of health workers designated for NCD-related health services.

"*...there is a lack of trained health workers for the care of elderly people suffering from chronic illness ...*"

-Policy research on health-related SDGs in Nepal,2017

Most of the FGD participants and IDIs mentioned that no health workers had been specifically designated for NCD-related services. Health workers at the local and provincial levels across all three provinces described that more than half of the allocated positions were vacant, even though the number of sanctioned positions compared to the daily workload is already very low. A similar opinion regarding the poor retention of trained health workers was expressed by municipal and provincial program managers in Bagmati province. All FGD participants mentioned that there was a crisis of NCD-specific health workers like ECG technicians, dieticians, radiotherapy technicians, anesthesia technicians, operation theater technicians and other technical workers for NCD care. The municipal program manager in Bagmati province emphasized that the clinical knowledge and skills with regards to NCD treatment was poor among primary health care workers. In contrast, the program manager in Karnali province reported that there was no issue with retaining health workers; he stressed, however, that the poor competencies among them were an issue.

"*...despite designated positions, there has been no psychiatrist and cardiologist in provincial headquarters for the last six months*," *-IDI in Gandaki province*

Federal and provincial policymakers both mentioned that the domestic education and training of human resources for health (HRH) had improved in recent years but that the proportionate skill mix of health workers had not been fulfilled yet. The policymaker at the federal level indicated that health workers' sense of serving had been diverted to earning; as a result, trained health workers were migrating due to a poor retention strategy in Nepal.

"*...brain drain is one of the key human resources for health problems in the Nepalese health system, the retention strategy needs to be revisited...*" *-IDI in federal level*

Health logistics

Three guiding policies and one implementing policy described the importance of health logistics for the prevention and control of NCDs and their risk factors. Most of the policy statements on health logistics focus on drugs and few of them spell out the need for equipment/ instruments for diagnosis of NCDs. All policy documents mention that commonly used NCD drugs at primary health care level should be available to patients free of charge.

"....*NCD services aim to ensure the availability of basic technologies and essential medicines at the primary health care level free of cost*....." *- NCDs-Multi Sectoral Action Plan,2014–2020*

Most FGD participants referred to the scarcity of NCD drugs, equipment and instruments at the primary health care level. They further mentioned that the regular supply of health commodities–as well as their quality–was a constant problem. FGD participants emphasized that most of the municipal authorities perceived drugs as 'the only commodity of relevance for NCD prevention and control, neglecting the need for diagnostic equipment and infrastructure. The problem of diverged costs and the poor quality of drugs and reagents procured by municipal authorities was raised during the IDIs with provincial policymakers in three provinces. Similarly, the interview with the federal policymaker revealed that local- and provincial-level purchase decisions were not guided by realistic demand forecasts, resulting in much variation in cost and quality.

".....*Procurement decisions are not guided by a procurement plan, and most of them have no idea about demand forecasting*....." *-IDI in federal level*

The municipal program manager in Karnali province stated that NCD-related health commodities were sufficiently available. In contrast, health workers described that the supply of drugs and laboratory reagents from the municipality was neither regular nor timely.

"....*we send the demand form with the list of drugs required for a month but the supply is incomplete and sufficient only for half a month, the next supply is not certain*...." *-IDI in Karnali Province*

Provincial FGD participants reported that the quantity of health commodities was sufficient but that regular and timely supply of commodities was not possible due to lengthy procurement processes. The program manager in Bagmati province stated that a modernized laboratory had been established at municipal level but that the quality of equipment, instruments, medicines and reagents was questionable due to the legal requirement to procure health commodities at the lowest possible cost.

A notable comment by the provincial program manager in Karnali province revealed that medical equipment, once installed in hospitals, was rarely repaired. None of the policy makers, program managers and health service providers referred to the health logistics focusing on the health needs of the elderly population.

Health financing

Two legal policies, five guiding policies, four implementing policies and three commission/ study reports described issues related to health financing for the prevention and control of NCDs. The review of these policy documents revealed the low priority given to NCD interventions during the allocation of financial resources. The policy statements also described that a lower than WHO-recommended proportion of the overall government budget was allocated to the health sector. None of the policy documents identified a dedicated budget for the prevention and control of NCDs, the available limited budget had been allocated to curative services. A report for the assessment of the NCD Multi sectoral Action Plan, 2014–2020 recommended that existing resources need to be re-directed towards preventive and promotive interventions targeting NCDs and their risk factors. The national report on SDG progress, 2016–2030 stated that existing priorities of external development partners and donors for NCDs were not sufficient. Some policy documents reported on a social security mechanism for poor and disadvantaged people but the administrative procedures of obtaining support were complex and the amount of support was insufficient relative to the cost of care. The national report of the Nepal NCDI poverty commission recommended that NCD interventions require 22% of total health expenditure or roughly $8.76 per capita expenditure or 1.4% of current GDP. Most of the policy documents referred to the progressive taxation on tobacco, alcohol and sugar-sweetened beverages as a key financing mechanism for tackling NCD risk factors.

"..... *taxation on alcohol, tobacco and sugary drinks would be the financing technique for the prevention and control of NCDs and their risk factors*....."

- Integrated policy for prevention and control of NCDs, 2006

Most of the FGD participants remarked that in ranking different sectors in terms of budget allocation, the health sector ranked below five. Furthermore, the budget allocated to NCDs was described as less than 10% of the overall health sector budget. The municipal program manager in Bagmati province believed the health sector budget to be sufficient but emphasized that the NCD-specific budget was negligible. Most of the IDIs from Gandaki and Karnali provinces reported that the overall health budget was not satisfactory and that most of the budget allocated to NCD services was

used to purchase drugs. Similarly, health workers in Karnali province mentioned that the NCD budget at municipal and provincial levels was assigned to drugs and diagnostics.

"*.....politicians' priority is the construction of roads and bridges. Whatever budget is allocated for the health sector is spent on drugs for free distribution.....*" *-IDI in Karnali Province*

A notably different opinion was expressed by the provincial policy maker and program manager in Gandaki province. According to them, the provincial government paid appropriate attention to the financial needs of the health sector and prioritized NCDs over other health sector needs. Health workers in Bagmati province mentioned that the municipal health budget had been allocated to the free supply of drugs and laboratory tests targeting the elderly population.

Health information and surveillance

Three guiding policies, two implementing policies and three commission/study reports referred to health information and surveillance. According to these, existing monitoring and reporting tools of the health management information system (HMIS) need to be revised to include more NCD-relevant variables; policy documents emphasized disease monitoring and tended to neglect risk factor monitoring. A report on policy research on the health-related SDG in Nepal explored the need for NCD-specific surveillance mechanism to ensure the effective and regular monitoring and assessment of NCDs and their risk factors. All policy documents mentioned the importance of using the evidence for sufficient drug supply, budget estimation and program decisions.

"*...surveillance, monitoring, evaluation and research as one of the four action areas for realistic estimation of the burden due to NCDs....*" *-NCD Multi sectoral Action Plan,2014–2020*

All FGD participants mentioned that there was a well-established HMIS for recording and reporting of routine health services data but that monitoring and reporting mechanisms for NCDs and their risk factors was lacking. The municipal program manager in Bagmati province and the service provider in Gandaki province both expressed a similar opinion about the lack of NCD- specific surveillance mechanisms, notably with regards to risk factors. NCDs were rarely if ever discussed at monthly monitoring meetings in Bagmati and Gandaki provinces.

"*...the municipal monthly review meeting for monitoring HMIS data focuses on priority public health programs, e.g. immunization, family planning, etc. NCDs and risk factors are never discussed...*"

-IDI in Bagmati Province

Notably, the municipal program manager and service provider in Karnali province described the existence of a separate NCD monitoring and reporting mechanism in areas where the PEN package had been implemented. Here, NCD data were also discussed during the monthly monitoring meetings at municipal level. A service provider working in a health post that implemented PEN reported that they were using a separate tool for monitoring and reporting on NCDs and their risk factors.The federal level policy maker stated that data generated from the monitoring and reporting of routine health services had been used in the annual report but had not been used for program decisions.

"*....it is good to publish the annual report, but that report is being studied seldomly. Reviewing and using the evidence in annual reports for policy decisions should be promoted...*"

-IDI in federal level

Governance and leadership

For the prevention and control of NCDs and their risk factors the issue of governance and leadership was explicitly mentioned in the majority of policy documents, notably in one legal policy, twelve guiding policies, three implementing policies and four commission/study reports. These revealed that some attention had been paid to the control of NCD risk factors through health promotion strategies, taxation of health-harming products and the construction of cycling lanes, pedestrian trails, public parks, gyms and yoga halls in urban area. These interventions require multisectoral engagement but, in reality, the contribution of sectors other than health is negligible.

"*... a need for multisectoral coordination with agricultural, environment and education sectors to enhance their role in health promotion....*" *-National Health Policy,2019*

Municipal FGD participants mentioned that preventive and promotive services targeting NCDs were not prioritized. A similar opinion was expressed by municipal health coordinators in Gandaki and Bagmati provinces, where the health sector was not ranked among the top ten of fifteen priority sectors. IDIs with service managers revealed the perception of political leaders that spending on drugs and doctors was sufficient for achieving better health and that health investments beyond these aspects represented a waste of resources.

"*...for politicians plenty of free drugs and around-the-clock availability of doctors in hospitals are sufficient for better health of the people....*" *-FGD in Karnali Province*

Provincial program managers in Bagmati, Karnali and Gandaki provinces stated that the overall priority assigned to the health sector by political leaders was very low because most of them had only

limited awareness of the burden of NCDs and associated risk factors. In their view, this explained the higher priority given to hospitals, lab tests and drugs and the relative neglect of preventive and promotive services. A contradicting opinion was expressed by a provincial program manager in Karnali province who felt that political leaders and decision makers had sufficient knowledge about NCDs and their underlying risk factors.

"*...political leaders have good knowledge and ideas about NCD prevention and control*, *they draft very nice policy documents but their implementation is not so exciting*..." *-IDI in Karnali Province*

All FGD participants and IDIs reflected that provincial governments paid greater attention to interventions targeting NCDs than local governments. Similarly, NCD-specific programs had received greater attention at the federal level compared to provincial and local levels. The federal policy maker reported that NCD-related services financed through federal budgets had been coordinated by the 'NCDs and mental health section' at the department of health services. He further stated that the 'poor consumption of the health budget' and 'program implementation focusing only on physical targets' are key governance issues. A critical concern was expressed with regards to the interrupted functional relationship between different levels of healthcare after the federal restructuring of the health sector.

"*...we are focusing on the achievement of physical targets*, *not on the effectiveness and efficiency of health interventions*....." *-IDI in federal level*

Discussion

This study is, to our knowledge, the first study that has examined the readiness of the Nepalese health sector with regards to the prevention and control of NCDs and their risk factors, based on the policy documents and, notably, the perceptions of the health workforce and health decision makers. Health sector policy documents identified in this study were found to be sensitive towards the growing burden of NCDs, but less so to the need to address risk factor for NCDs (Table 4).

Existing policy priority was thus focused on curative services with preventive and promotive interventions being neglected. Poor retention of trained health workers represents an old and continuous problem. More than half of the positions designated for NCDs were vacant resulting in too high a workload across all levels of health care. Inadequate quantity and quality of health commodities emerged as a key logistics issue. Inadequate budget allocation made for NCDs was also apparent, planning and program decisions regarding NCDs did not make use of available evidence.

Engagement of non-health sectors with the prevention and control of NCDs was largely absent. In summary, a key finding obtained from this study is that the level of the health policy commitment is not sufficient to respond to the growing burden of NCDs. There is a gap between the design and implementation of policy into practice for the prevention and control of NCDs, with significant weaknesses apparent in each of the six-health system building blocks. Moreover, there is a need for a policy and program reform to redirect health sector priorities towards the control of NCD risk factors.

Many governments in LMICs seek a solution for the increasing health and financial implications of the NCD burden [25], however, the Nepalese effort appears to be motivated only by the health implications of NCDs. While the global status report on NCDs describes the vicious cycle between NCDs and poverty [26] none of the policy makers and program managers in Nepal consulted in this study made reference to these links.

In the UN Political Declaration on NCDs heads of state committed themselves to the development of national targets and indicators based on the specific national situation [7] Nepal has drafted a multisectoral action plan [16] in a timely manner, but national targets with relevance for the domestic context have not yet been set, as confirmed in this study. There is also a recommendation for routine and robust surveillance mechanism for NCD risk factors [27]. In Nepal, however, routine surveillance through the HMIS does not yet target NCD risk factors or NCD mortality, but instead focuses on NCD-related morbidity data.

Table 4. Summary findings regarding perspectives on health sector readiness for NCD prevention and control.

SN	Building blocks	Key findings	
		Findings suggesting health sector readiness	**Findings suggesting a need for improvement in health sector readiness**
1	Health service delivery	• NCDs services, where available, represent components of basic health services. • The Package of Essential NCD services (PEN) is available at the primary care level. • Services focused on curative services and targeting diseases are available.	• There are no specific health services targeting NCDs. • Health services targeting the health needs of the elderly are not specified. • Preventive and promotive services targeting risk factors receive far less priority than curative services.
2	Human resources for health	• PEN-trained health workers are more competent than non-PENtrained health workers.	• In rural location there is poor retention of general health workforces but in urban location the trained health workforce is not available; reflecting brain drain. • More than half of the positions are vacant, implying that those working are overburdened. • There is no health workforce specially trained for NCD services. The required skill mix of the workforce is not being met.

3	Health commodities/ logistics	• Logistics focus on NCD drugs.	• Logistics rarely cover diagnostics, equipment, and instruments. • Problems with health commodities include inadequate quality and quantity, and lack of a regular and timely supply. • Repair and maintenance of equipment/instruments does not occur frequently.
4	Health financing	• During budget allocation, priority is given to curative aspects rather than preventive aspects.	• Limited priority is awarded to NCD-related activities in comparison with infectious disease-related activities. • There is no dedicated budget for NCD-related interventions, and the budget consumption rate is slow. • Funding support from external development partners for preventive interventions is negligible.
5	Health information and surveillance	• The current health management information system covers NCDs.	• The current health management information system does not cover NCD risk factors. • Monthly monitoring meetings lack discussions about NCDs. • NCD-related program decisions do not tend to use evidence.
6	Leadership and governance	• The 'NCDs and mental health section' at the MoHP coordinates NCD-related services. • Some–but very few–efforts to address NCD risk factors have been made by local government, including the construction of cycle lanes, pedestrian trails, public parks, gyms, and a yoga hall.	• Interrupted functional relationships between different levels of healthcare after the restructuring of the health sector is a key governance problem. • Provincial governments tend to pay greater attention to interventions targeting NCDs than local governments. • Engagement of non-health sectors with prevention and health promotion activities is negligible; the health sector receives less priority compared to other sectors, at all levels of government and among political leaders.

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Scientific evidence demonstrates that the burden of NCDs and their associated risk factors can be reduced through effective preventive and health-promotive health services [10, 28]. However, health services offered at federal, provincial and local health facilities in Nepal concentrate on curative services. More broadly, existing wide disparities in access to health services and high out-of-pocket expenditures on health care are increasing in LMICs [29], with Nepal being no exception. The target for the allocation of government funding to health, which is recommended to be at least 22% of total expenditure [26], has not yet been achieved in Nepal.

Inadequate human resources in the health systems of LMICs represent a well-described problem [16]. The Nepalese health system suffers from, among others, a poor retention of health workers and an inappropriate skill mix, with wide ranging impacts for population health in general and for NCDs in particular [30]. One approach to overcoming the latter problem would be to make training on the prevention, diagnosis and treatment of NCDs compulsory for all health workers, most importantly, a basic package needs to be incorporated in the preservice training curriculum of primary care health workers [31, 32].

Similarly, the availability of essential medicines and commodities, and functional logistics are critical components for primary health care to be able to respond to NCDs and their risk factors in an appropriate manner [32]. This study has shown that there is a problem with poor quality and quantity of essential medicines, laboratory reagents, equipment and instruments purchased and supplied by provincial and local governments in Nepal.

A study assessing service availability and readiness for NCDs in Bangladesh found that the NCD service available only target cardio-vascular diseases and diabetes mellitus and are only available at and above municipal level [33]. A qualitative assessment of health system preparedness in India [34] and Thailand [35] showed a low level of preparedness as well as low community engagement with NCD prevention and control. Low levels of readiness for major NCDs have also been commonly reported in Zambia [36] and Ghana [37]. All of these studies had used qualitative approaches with some quantitative triangulation.

The increasing burden of NCDs and an ageing population, means that efforts to prevent and control NCDs should pay particular attention to the growing elderly population in Nepal [38]. In this study, neither the documents reviewed nor the stakeholders interviewed explicitly referred to the specific health needs of Nepalese elders, neither in the context of NCDs nor with regards to meeting the targets under the UN decade of healthy ageing [39].

Age effects on NCDs and their risk factors are yet to be explored in the Nepalese context so that evidence-informed policies, plans and programs can be designed and implemented for the prevention and control of NCDs among older population.

Strengths and weaknesses

A key strength of the present study is that it generated and combined insights from three distinct qualitative approaches (i.e. policy document review, FGDs and IDIs) and from a range of perspectives across different levels of the health system. It has also sought to capture insights from three provinces representing Nepal's three distinct eco-political regions. A weakness is that insights at the federal level were mostly drawn from policy documents and an interview with the single participant from the MoHP.

A significant limitation is that early stages of the analysis were only undertaken by a single person. Moreover, the study is solely based on qualitative methods albeit using different information sources.

A mixed-methods study could contribute more representative quantitative insights and would enable the triangulation of qualitative and quantitative data.

Data collection for the policy documents made use of systematic searches; in addition, it benefited from the guidance of an MoHP official with almost two decades of experience in the Nepalese health sector. However, the review of policy documents focused on the health sector and may therefore have missed relevant policy documents drawn up by other sectors. We cannot exclude the possibility that BPS being the interviewer in FGDs and IDIS and working for the MoHP may have created social desirability bias among respondents.

Qualitative data analysis was guided by the WHO health system building blocks framework, thereby ensuring a structured approach and international comparability. However, qualitative data analysis was largely performed by one person (BPS) with input from all authors; joint coding and analysis of all data would have been preferable. Also, data were collected in Nepali, translated into English and then analyzed in English, which may have yielded minor errors in translation and interpretation, although BPS checked all translations against the IDI and FGD transcriptions.

Conclusion

This study has revealed important limitations in the readiness of the Nepalese health sector to respond the growing NCD pandemic, pointing to the need for reform. There is a critical gap in the formulation and implementation of NCD-targeted policies and community-based programs–notably with regards to implementing evidence-based interventions to promote healthy diets and physical activity and to strengthen preventive interventions concerned with tobacco and alcohol consumption–across the six building blocks of the health system.

With an increasing life expectancy, a growing elderly population will further exacerbate existing problems and this must be taken into account in advancing the health sector response to NCDs. Moreover, urbanization and changed lifestyles in Nepalese society must be considered, and sectors other than health involved with successful prevention and control of NCD risk factors.

Much of this study's assessment of health sector readiness is derived from the perceptions of different cadres of health workers and health decision-makers at national, provincial and community levels; future research should follow up with a quantitative assessment of health sector readiness, trying to triangulate qualitative and quantitative insights.

Supporting information

S1 Dataset. Minimum dataset used for qualitative analysis.(XLSX)

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4.2 Paper B

Effects of age on non-communicable disease risk factors among Nepalese adults.

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Effects of age on non-communicable disease risk factors among Nepalese adults

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Abstract

The growing burden of non-communicable diseases (NCDs) and an increase in the prevalence of the underlying risk factors are creating a challenge to health systems in low- and middle-income countries (LMICs). In Nepal, deaths attributable to NCDs have been increasing, as has life expectancy. This poses questions with regards to how age and various risk factors interact in affecting NCDs.

We analyzed the effects of age on NCD risk factors, using data from the Nepalese STEPs survey 2019, a nationally representative cross-sectional study. Six sociodemographic determinants, four behavioral risk factors, and four biological risk factors were examined. Age effects were analyzed among three age groups: below 35 years (young), 35-59 years (middle aged) and 60 years and above (elderly).

The prevalence of selected behavioral risk factors for NCDs, notably smoking, alcohol consumption and insufficient physical activity, and some biological risk factors (hypertension, hyperlipidemia) increases with age. The prevalence of most behavioral risk factors was highest among men and women aged 60 years and above. The prevalence of hypertension and hyperlipidemia was highest among the elderly, but the prevalence of diabetes and overweight/obesity was highest among the middle aged for both sexes. Age interactions in the association between behaviors and biological risk factors were surprisingly weak. However, age interactions were significant in the association between alcohol consumption and -hypertension, -overweight/obesity and -hyperlipidemia among women.

While the prevalence of NCD risk factors tends to be higher among elders, the interaction between age and risk factors is complex. Most NCD risk factors are related to behaviors, which originate in young adulthood. It is necessary to diagnose and treat biological risk factors, in younger age groups before they manifest as NCDs. Similarly, behavior change interventions need to target these younger age groups to reduce the risk of NCDs later in life.

Background

There is a growing pandemic of non-communicable diseases (NCDs), such that cardiovascular diseases, diabetes, chronic respiratory diseases and cancers are now the leading causes of global deaths[1].The global NCD burden is high and the NCD share of global deaths increased from 68% in 2012 to 71% in 2016[2] and 74% in 2019 [3]. However, NCDs are not inevitable[4].It is estimated that 17 million NCD-related deaths occur before the age of 70 and are largely preventable[5].Most NCDs are initiated in early life and occur as the result of an unhealthy lifestyle[6]. Modifiable

behavioral risk factors (i.e. tobacco use, harmful use of alcohol, unhealthy diet and physical inactivity) and metabolic biological risk factors (i.e. raised blood pressure and blood glucose, abnormal lipids and overweight or obesity) contribute the most to the development of NCDs[7]. The prevalence of these risk factors is boosted by an aging population, an increasing life expectancy, and by urbanization[8]. Aging and an unhealthy lifestyle are the major driving factors for common NCDs in modern-day society[9]. Moreover, there is a socio-economic gradient in the presence of these risk factors within any given population [10].

The burden of NCDs is especially high in low- and middle-income countries (LMICs), where the majority (86%) of premature NCD-related deaths globally occur[5]. In low-income countries, 22% of men and 35% of women are losing their life due to NCD-attributable premature deaths, while in high-income countries the corresponding numbers are 8% and 10%, respectively [4]. In Nepal, risk factors beyond the above described classical NCD risk factors, such as household air pollution from solid fuel use, poor oral health and high salt consumption, further contribute to the development of NCDs [11,12]. Estimated premature deaths attributed to NCDs in Nepal increased from 51% in 2010, to 60% in 2014 and further to 66% in 2016 [13]. Life expectancy for Nepalese people has increased from 67 years in 2011[14] to 71 years in 2019[15]. Aging is inevitable but the higher prevalence of NCDs in an ageing population creates a challenge for health systems[16].

Although demographic aging has been recognized as a key risk factor for the development of NCDs in LMICs[17], it has not been explored how age affects and interacts with NCD risk factors in the Nepalese context. As a member state of the World Health Organization (WHO), Nepal is committed to achieving the WHO's 25 by 25 strategic health goals for a reduction of NCD-related premature deaths by 25% by 2025[18], but effective public health interventions targeting the aging population are yet to be designed and executed. Similarly, the UN Sustainable Development Goal (SDG) target 3.4 [19] calls for all member states to reduce premature mortality from NCDs by a third between 2015 and 2030. Recent reports noted, however, that most LMICs are off track to reach SDG target 3.4 for NCD mortality[20] .

This study aims to assess the effects of age on behavioral and biological risk factors of NCDs by exploring the following research questions:

- How do behavioral and biological risk factors vary with age?
- How does age modify the effect of health behavior on biological risk factors?

Methods

Study design and study population

This cross-sectional study is based on data from the STEPs survey 2019, a nationally representative population-based household survey of adults aged 15-69 years targeting NCD risk factors and conducted by the Nepal Health Research Council[21].Using a multistage cluster sampling technique, from each of the seven Nepalese provinces, 37 community clusters were randomly selected, thus resulting in 259 primary sampling units (PSU). From each PSU, 25 randomly selected households were included in the study and one adult per household was enrolled.

Data collection was interview-based, used the standardized NCD STEPS questionnaire version 3.2 [22] and was conducted between February and May 2019 in three phases. The first and second phases were performed at the participant's home, where socio-demographic characteristics and self-reported behavioral data were collected and physical measurements for height, weight and blood pressure were taken. The third phase was performed at a health facility located within the community cluster[21].The overall response rate to the STEPs survey was 86.4%[21].

Study variables

Our study includes three categories of variables based on an underlying conceptual framework *as illustrated in figure 1*.

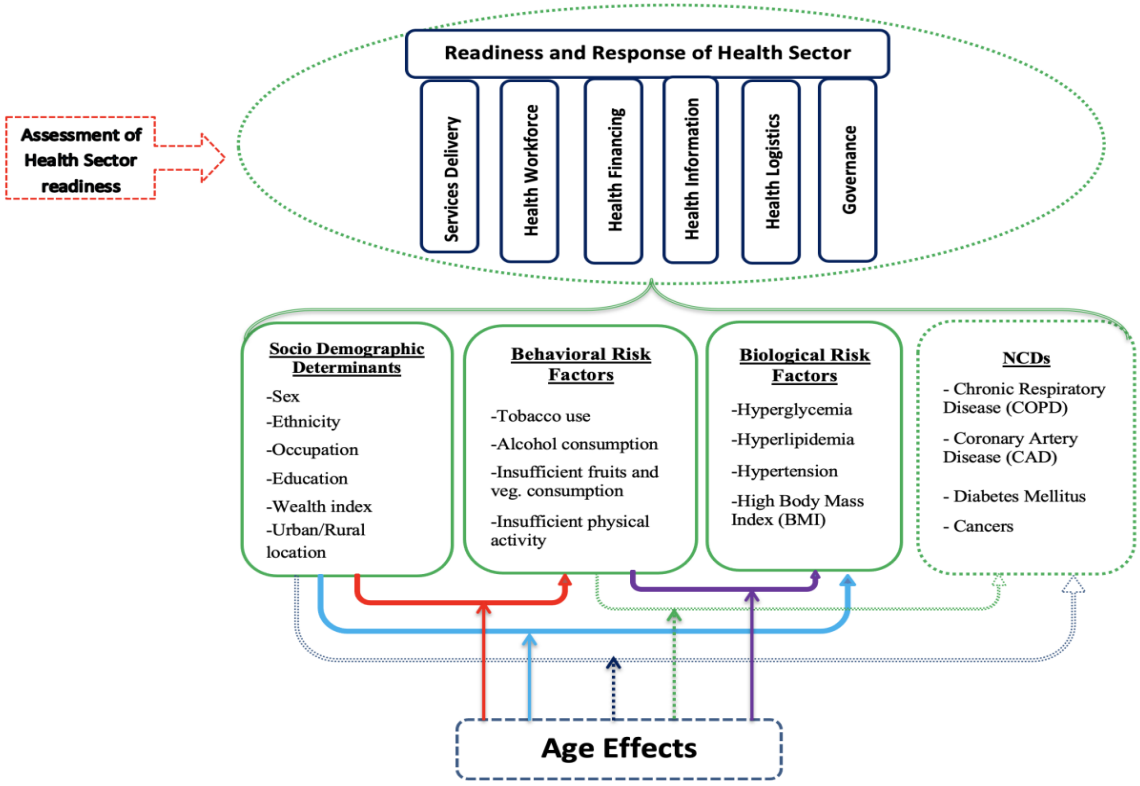

Figure 1: Conceptual framework of the study

Sociodemographic characteristics: age, sex, ethnicity, highest level of education, current occupation, wealth index and urban or rural location of the community.

Behavioral risk factors*:* daily smoking, any alcohol consumption in the last 12 months, insufficient fruit and vegetable consumption, insufficient physical activity.

Biological risk factors*:* overweight or obesity measured by BMI, hypertension (raised blood pressure or current use of antihypertensive drugs), hyperglycemia (raised blood glucose or current use of hypoglycemic drugs) and hyperlipidemia (raised total cholesterol or current use of lipolytic drugs)

Details about the definition and levels of these binary and categorical variables are described in the ***supporting information 1 (S1).***

Data analysis

Statistical analyses were conducted using the statistical software R, version R 4.1.1[23] using the libraries survey[24] and mgcv [25]. Analysis used inverse probability weighting based on the sampling probabilities to adjust for differences in the age and sex composition of the sample

population compared to the Nepalese population[26]. There was minimal missing data, therefore the analyses are based on complete cases. All analyses were stratified by sex.

Distributions of sociodemographic characteristics of the study sample are reported unweighted in table 1. The prevalence of behavioral and biological risk factors was estimated by weighted frequencies and these are reported together with their Standard Errors (SE) in table 2. To investigate differences in the magnitude and pattern of the NCD risk factors by age, descriptive and prevalence estimates are stratified by the age groups "15-35 years", "35-59 years" and "60 years and above", and p-values based on Chi-square tests are reported.

Weighted multilevel logistic regression for clustered survey data was used to assess the association of sociodemographic characteristics with behavioral risk factors (table 3) and the association of behavioral risk factors with biological risk factors (table 4). Age was included in all models as a categorical variable to investigate age effects. Regression models were fitted without and with adjustment for sociodemographic variables. Odds Ratios (OR) and adjusted Odds Ratios (AOR) are reported together with 95% confidence intervals.

Ethical approval

Permission to use the 'STEPS survey-2019 dataset' for this study was obtained from the Nepal Health Research Council (NHRC) by letter (reference no. 786). Ethical approval for the study was obtained from the NHRC (reference no. 2882) and from the ethical committee of the Munich Medical Research School, Ludwig Maximilians University (LMU) Munich, Germany (project no. 20-657). As the study represents a further analysis of the STEPS survey-2019 dataset, there was no need to obtain informed consent from study participants.

Results

Sociodemographic characteristics

The total sample population (n=5593) had a mean age of 35.0 years (standard deviation SD = 14.4 years) with 64.3% of the sample being female (Table 1). More than one-third of the participants belonged to the upper caste and almost one-third were disadvantaged Janajati. Nearly half of the participants were illiterate or had not completed their primary education. More than half of the participants were engaged as homemakers and non-paid workers, and more than 60% were residing in an urban location. ***(Table 1)***

Weighted proportions of sociodemographic characteristics illustrate that the sample population represents the Nepalese adult population very well when compared to the census report of 2011 [27]. Moreover, the weighted proportion of men and women was equally representative across the three age groups as illustrated in ***supporting information 2 (S2).***

Prevalence of behavioral and biological risk factors

Daily smoking increased significantly with increasing age, among both sexes (Table 2). But the increase was far stronger in women, ranging from 1% prevalence for the youngest to 12% among the middle aged and 23% for the oldest age group. Among men, the prevalence of daily smoking increased from 17% among the youngest age group to 24% among the middle aged and 30% in the elderly. Similarly, alcohol consumption increased substantially with age among women from 7% prevalence in the youngest age group to 18% in the oldest age. In contrast, for men, prevalence of alcohol consumption was highest (44%) among 35-59 year-olds, followed by 38% among <35 year-olds and 34% among those aged 60 years and older. The highest prevalence of insufficient physical activity was found in the age group 60 years and above, higher among men than among women (27% vs. 20%), while there is not much difference in physical inactivity between sexes for other age groups. Insufficient fruit and vegetable consumption was very high for all age groups with about 5 out of 6 adults having two or less servings per day.

The prevalence of the two biological risk factors hypertension and hyperlipidemia showed significant differences between males and females. Hypertension was significantly more common in males ranging from 10% among those aged below 35 years, to 33% among those aged 35-59 years and 46% among those aged 60 years and above. Hyperlipidemia was more common in females, ranging from 8% among those aged below 35 years, to 19% among those aged 35-59 years and 32% among those aged 60 years and above. The prevalence of both increased substantially with age so that nearly half of the men of the oldest age group suffered from hypertension and nearly every third woman of this age had hyperlipidemia. Overweight and obesity was about equally prevalent in men and women, with the prevalence being highest in the middle-aged population (35-59 years), where one out of three adults was affected. Also, the prevalence of hyperglycemia was highest among 35-59 years old (9% in men and 8% in women), followed by the oldest age group (8% in men and 7% in women).

(Table 2)

While the prevalence of biological risk factors in Nepal is high, levels of diagnosis and treatment remain very low. Only 13% of the respondents with hypertension reported taking antihypertensive medicines, and only one out of 10 diabetes patients reported taking hypoglycemic medicines. For

hyperlipidemia the treatment rate was as low as 2%. The treatment rate was lower among women compared to men, and lowest in women and men aged 60 years and older.

Age and sociodemographic effects on behavioral risk factors

A multiple regression model including all sociodemographic variables jointly showcased other relevant characteristics associated with health behaviors and biological risk factors.

Daily smoking significantly increased with age among women, but not among men. In addition, daily smoking significantly differed among ethnic groups, being highest among Dalits. While a higher educational attainment reduced the prevalence of smoking in both sexes, higher wealth only reduced smoking among women; in contrast the chances of smoking were 38% higher among men of a middle wealth index compared to men of a low wealth index.

Alcohol consumption was significantly more prevalent among women of higher age groups, yet it was significantly lower among men aged 60 years and above. Apart from this, alcohol consumption showed a similar but less pronounced picture as described for tobacco use above. The ethnic group with the highest prevalence of alcohol consumption was the advantaged Janajati.

Insufficient fruit and vegetable consumption significantly differed between ethnic groups. For men it was lowest in religious minorities, while for women it was lowest among the advantaged Janajati and upper caste. Higher educational attainment reduced the prevalence of insufficient fruit and vegetable consumption among men, less so among women.

Insufficient physical activity was highest in the oldest age group for both, men and women, and among those living in an urban location. ***(Table 3)***

Effects of health behaviors on biological risk factors and their associations with age

The risk of **hypertension** was found to be associated with alcohol consumption among men after being adjusted for sociodemographic factors. However, this effect was evened for the oldest age group. Besides that, age affected the prevalence of hypertension as described above.

After adjustment for sociodemographic variables, the risk of **diabetes** was not significantly associated with any of the behavioral risk factors but increased with age.

The prevalence of **overweight and obesity** was found to be significantly associated with alcohol consumption for young women. But this effect was leveled out again by the age interaction for the two older age groups. The risk of overweight and obesity was highest among 35-59 years old.

Also, the prevalence of **hyperlipidemia** was found to be significantly associated with alcohol consumption for young women. The risk of suffering from hyperlipidemia increased with age, and this age effect was stronger among women than among men. The effect of daily smoking on hyperlipidemia was not statistically significant, which could be due to the masking effect of age on hyperlipidemia. The interaction of age and alcohol consumption for the two older age groups was found to reduce this increased risk of hyperlipidemia. Also, the effect of physical activity on hyperlipidemia among women significantly differ between the youngest age group (below 35 years) and 60 years and above aged women. ***(Table 4)***

Discussion

Key findings

Existing literature suggests a higher prevalence of NCDs and their risk factors among the older population but the modifying effect of age on the associations between behavioral and biological risk factors for NCDs has not received much attention to date. This study, to our knowledge the first of its kind in LMICs like Nepal, shows that:

The prevalence of selected behavioral risk factors for NCDs, notably smoking, alcohol consumption and insufficient physical activity, increases with age. The prevalence of the biological risk factors hypertension and hyperlipidemia significantly increases with age. Among the elderly, i.e. those aged 60 years and above, hypertension affects every third man and more than one in five women; in addition, more than a third of elderly women suffer from hyperlipidemia. Overweight and obesity as well as diabetes are significantly more prevalent among 35-59 year old Nepalese adults. In this middle-aged population, every third person is overweight or obese and 8% and more suffer from diabetes. This finding might point towards a generation effect.

In our study, the most important factor influencing the prevalence of behavioral and biological risk factors for NCDs, is age. In contrast, age interactions in the association between behavioral risk factors and biological risk factors were surprisingly weak, with only alcohol consumption in women showing a significant impact on the biological risk factors

hypertension, overweight and obesity and hyperlipidemia. Levels of diagnosis of and treatment for these biological risks are, however, very low in Nepal.

Results in context with existing findings

In line with our findings previous studies in LMICs have indicated that older populations of lower socioeconomic status are more likely to use tobacco, alcohol and eat unhealthy diets [28,29]. A European study showed overweight/obesity and physical inactivity to be the most prevalent NCD risk factors[30], while our study revealed overweight/obesity and hyperlipidemia for women and alcohol consumption and hypertension for men as the most common NCD risk factors in Nepal. The findings of previous studies among adults from eleven European countries [31] are similar to our study, showing that behavioral risk factors are more prevalent among men while biological risks factors, specifically overweight/obesity and hyperlipidemia, tend to be more common among women.

Previous studies revealed that hyperlipidemia is more common among smokers[32]. A randomized clinical trial in the USA suggested that current smoking is associated with raised total cholesterol and triglycerides in the blood[33] while our study suggests that risk of hyperlipidemia increases with age but not with smoking.

Hypertension was observed to only be determined by age, and no relationships with other risk factors were observed except for alcohol consumption in the last 12 months among women. Similar findings were reported in an Indonesian study from 2018, which suggested that there is no relationship between smoking and hypertension[34]. This, however, is likely due to limitations of the cross-sectional study design, as longitudinal studies show a clear relationship between smoking and hypertension[35].

The effect of alcohol consumption on blood pressure may vary between males and females, indicating that low to moderate alcohol consumption may have a protective effect in females [36]. In contrast, our study examined the effect of alcohol consumption in three different age groups and suggests that the risk of hypertension is significantly increased by alcohol consumption in women. This association between alcohol consumption and hypertension, however is not observed for the older age group, where the effect is leveled out by the interaction effect with age.

A meta-analysis investigating the effects of alcohol consumption on overweight and obesity showed varying results. A cohort study showed that there was no significant association between drinking alcohol and overweight and obesity but in cross-sectional studies, alcohol intake was found to be

associated with overweight[37]. Our study shows a significant association between alcohol consumption and overweight and obesity in young women. This is, however, not observed in the older age groups or in men.

A study in China suggested that the prevalence of hyperlipidemia was positively correlated with alcohol consumption[38], which is supported by the findings of our study showing a strong association between alcohol consumption and hyperlipidemia in young women.

Strengths and limitations

A major strength of this study is that it is based on a large, well designed and nationally representative survey using the WHO standardized STEPS survey tool. This survey offers an elaborate survey design that ensures representativeness of the data with negligible missing values, and guarantees a high degree of quality control during data collection and data entry. Another point that contributes to the robustness of the results is the underlying, well-defined conceptual framework that guided our data analysis. All biological measures were taken by trained health care workers, thus ensuring higher quality than self-reported data would.

However, a limitation of the data set with regards to the impact of age is the cross-sectional nature of the data, which makes it difficult to disentangle effects between different generations from differences between different age groups. The statistical analysis did not use age as a continuous variable but as a categorical variable comprising three broad age groups. Among women, this may create a problem, as it may yield confounded effects of menopausal symptoms and hormonal changes among middle-aged women. To conclude on a causal effect of age longitudinal data would be needed. Also, the data is limited to the population up to age 69, thus ignoring the oldest within the Nepalese population. Additional weaknesses relate to the measurement of the behavioral variables, which are all self-reported. Tobacco consumption records only if any tobacco products are currently used but does not differentiate between smoking and use of smokeless tobacco products, nor does it measure the amount used. Given the large number of variables included in our analysis, we had to limit ourselves to one measure of tobacco and chose the one that would likely show the greatest effect. Alcohol consumption only documents any alcohol consumed within the last twelve months and thus might also be a proxy for general lifestyle and health behavior considering the multi-ethnical population of Nepal. The measure of fruit and vegetable consumption is unsatisfactory, as it does not allow a small degree in dietary variation to be captured. Consumption of fruit and vegetables is known to be very low in Nepal, and given the limited variation within the population, no significant effects are to be expected.

Conclusion

In Nepal, based on the findings of this study, age and sex exert a strong effect on the prevalence of behavioral and biological risk factors for NCDs and, ultimately, on the prevalence of NCDs. The WHO "25 by 25" goal requires a 25% reduction in premature NCD mortality by 2025. Our study suggests that one of the most important targets for Nepal is detection and effective treatment of the biological risk factors; hypertension, hyperlipidemia and diabetes, among younger age groups – notably among those aged 35-59 years, before they manifest as NCDs. The health system will need to react now and in planning for the future by paying greater attention to train health workers at all levels, and by appropriately equipping health facilities for the effective management of risk factors. In addition, all NCD risk factors will need to be tackled early in life among those aged less than 35 years and throughout life through both education and creating enabling physical, social and policy environments that allow people to pursue a healthy lifestyle. Preventing unhealthy behaviors among younger age groups will reduce the risk of biological risk factors and ultimately of NCDs in older age. Notably, ensuring a healthy diet for the younger generation will be an important means to prevent overweight and obesity in generations to come.

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Table 1: Sociodemographic characteristics of participants - stratified by age group (unweighted)

Demographic variables	aggregate frequencies (unweighted percentage) (n=5593)	stratified frequencies (unweighted percentage)		
		Below 35 years (n=2196)	35-59 years (n=2705)	60 years and above (n=692)
Gender				
Men	1998(35.7)	647(29.4)	1040(38.4)	311(44.9)
Women	3595(64.3)	1549(70.6)	1665(61.6)	381(55.1)
Ethnic Group				
Dalit	766(13.7)	347(15.8)	326(12.0)	93(13.4)
Disadvantaged Janjati	1640(29.3)	634(28.8)	809(29.9)	197(28.4)
Religious Minorities	174(3.1)	83(3.7)	76(2.8)	15(2.1)
Advantaged Janajati	899(16.1)	327(14.8)	458(16.9)	114(16.4)
Upper Caste	2124(37.8)	805(36.6)	1036(38.2)	273(39.4)
Level of education				
Primary incomplete	2792(49.9)	580(26.4)	1632(60.3)	580(83.9)
Primary complete	1051(18.8)	520(23.6)	463(17.1)	68(9.8)
Secondary	1573(28.1)	990(45.0)	547(20.22)	36(5.2)
University	176(3.1)	106(4.8)	63(2.3)	7(1.01)
Location				
Rural	2133(38.1)	824(37.5)	1052(38.8)	257(37.1)
Urban	3460(61.9)	1372(62.5)	1653(61.2)	435(62.9)
Strata				
Rural Municipality	2133(38.1)	825(37.5)	1052(38.8)	257(37.1)
Sub-/Metropolitan City	705(12.6)	282(12.8)	346(12.8)	77(11.1)
Municipality	2755(49.3)	1090(49.7)	1307(48.4)	358(51.7)
Wealth Index				
Lower Wealth Index	2715(48.5)	1035(47.2)	1320(48.7)	360(52.0)
Middle Wealth Index	949(16.9)	384(17.4)	451(16.6)	114(16.5)
Upper Wealth Index	1929(34.6)	777(35.4)	934(34.7)	218(31.5)

Table 2: Prevalence of behavioral and biological risk factors - stratified by sex and age group (weighted)

Behavioral and Biological variables	Frequencies (Weighted Percentage ± SE)										
	Men					Women					Total aggregate
	Aggregate	<35 yrs	35-59 yrs	>60 yrs	p-value*	Aggregate	<35 yrs	35-59 yrs	>60 yrs	p-value*	
Daily smoking (n=5593)	516 (20.8±1.7)	133 (17.2±2.6)	281 (23.7±1.9)	102 (29.9±4.1)	**0.01**	372 (6.7±0.7)	39 (1.4±0.3)	238 (11.6±1.3)	95 (22.7±2.8)	**<0.001**	888 (13.3±0.9)
Consumption of alcohol in last 12 months (n=5593)	876 (38.6±2.4)	276 (35.7±3.2)	489 (43.9±2.9)	111 (33.7±4.1)	**0.03**	469 (10.8±1.3)	123 (6.7±1.2)	278 (15.6±1.7)	68 (17.6±3.7)	**<0.001**	1345 (23.8±1.3)
Insufficient physical activity (n=5593)	302 (16.0±1.8)	90 (15.4±2.4)	145 (14.5±1.8)	67 (26.5±3.9)	**0.01**	510 (14.6±1.5)	206 (14.4±1.9)	218 (13.8±1.8)	86 (19.8±3.1)	0.23	812 (15.2±1.3)
Insufficient fruits veg consumption (n=5593)	1639 (81.7±2.3)	535 (84.1±2.6)	841 (77.7±3.1)	263 (84.3±3.0)	**0.05**	3123 (85.1±2.1)	1331 (83.8±2.8)	1447 (86.4±1.8)	345 (89.9±2.4)	0.12	4762 (83.5±2.2)
Hypertension (n=5593)	775 (32.1±1.9)	153 (23.7±2.6)	452 (40±2.2)	170 (50.1±3.9)	**<0.001**	867 (20.8±1.3)	181 (9.9±1.2)	506 (32.6±2.0)	180 (46.0±3.3)	**<0.001**	1642 (26.1±1.1)
Diabetes (n=5593)	142 (6.0±0.9)	24 (3.7±1.2)	89 (8.8±1.2)	29 (8.1±2.2)	**0.009**	188 (4.9±0.6)	40 (2.7±0.7)	120 (8.0±1.1)	28 (6.8±1.6)	**<0.001**	330 (5.4±0.6)
Overweight and obesity (n=5519)	530 (24.2±2.0)	126 (19.1±2.5)	334 (32.0±2.4)	70 (21.7±4.2)	**<0.001**	1007 (25.2±1.6)	357 (19.3±1.8)	563 (35.5±2.0)	87 (19.7±2.8)	**<0.001**	1537 (23.9±1.2)
Hyperlipidemia (n=5593)	191 (7.4±0.8)	39 (4.2±0.8)	123 (11.0±1.6)	29 (11.4±2.6)	**<0.001**	499 (13.4±0.9)	106 (7.5±1.1)	288 (18.8±1.5)	105 (31.6±3.3)	**<0.001**	690 (10.5±0.7)

* p-value of the Chi-square test for differences between age groups

Table 3: Effect of sociodemographic characteristics on behavioral risk factors - stratified by sex

Sociodemographic variables	Daily Smoking				Alcohol consumption in 12 months			
	Men		Women		Men		Women	
	Odds Ratio (95% CI)	p-value*	Odds Ratio (95% CI)	p-value*	Odds Ratio (95% CI)	p-value*	Odds Ratio (95% CI)	p-value*
Age Group								
Below 35 years	--	--	--	--	--	--	--	--
35-59 years	1.25 (0.95-1.64)	0.11	**3.80 (2.58-5.60)**	**<0.001**	1.23 (0.95-1.57)	0.10	**2.28 (1.68-3.09)**	**<0.001**
60 years and above	1.34 (0.93-1.94)	0.11	**5.71 (3.63-9.00)**	**<0.001**	**0.56 (0.39-0.81)**	**0.002**	**2.26 (1.45-3.53)**	**<0.001**
Ethnicity								
Dalits	--	--	--	--	--	--	--	--
Disadvantaged janjati	**0.52 (0.35-0.76)**	**<0.001**	**0.44 (0.29-0.66)**	**<0.001**	0.87 (0.59-1.29)	0.49	1.26 (0.83-1.91)	0.83
Religious minorities	**0.36 (0.15-0.83)**	**0.01**	**0.11 (0.02-0.54)**	**0.006**	**0.02 (0.05-0.13)**	**<0.001**	0.06 (0.01-4.67)	0.79
Advantaged janajati	0.66 (0.42-1.04)	0.07	**0.58 (0.37-0.92)**	**0.02**	1.45 (0.93-2.12)	0.10	**2.27 (1.47-3.51)**	**<0.001**
Upper cast	0.74 (0.51-1.08)	0.11	**0.63 (0.44-0.91)**	**0.01**	**0.63 (0.43-0.91)**	**0.01**	**0.15 (0.09-0.24)**	**<0.001**
Educational attainment								
Primary incomplete	--	--	--		--	--	--	--
Primary complete	**0.68 (0.50-0.93)**	**0.01**	**0.17 (0.10-0.30)**	**<0.001**	0.84 (0.62-1.14)	0.26	**0.68 (0.47-0.99)**	**0.04**
Secondary	**0.50 (0.37-0.67)**	**<0.001**	**0.09 (0.04-0.19)**	**<0.001**	0.79 (0.59-1.06)	0.11	**0.40 (0.27-0.60)**	**<0.001**
University	**0.08 (0.03-0.2)**	**<0.001**	0.14 (0.62-3.29)	0.30	**0.46 (0.27-0.80)**	**0.005**	0.67 (0.23-1.94)	0.46
Location								
Rural location	--	--	--	--	--	--	--	--
Urban location	0.77 (0.57-1.05)	0.09	0.84 (0.60-1.17)	0.30	0.82 (0.59-1.14)	0.24	0.84 (0.53-1.35)	0.48
Wealth Index								
Lower wealth index	--	--	--	--	--	--	--	--
Middle wealth index	**1.38 (1.02-1.87)**	**0.03**	**0.47 (0.33-0.68)**	**<0.001**	1.23 (0.91-1.64)	0.17	0.87 (0.62-1.23)	0.40
Upper wealth index	1.02 (0.79-1.31)	0.85	**0.33 (0.24-0.46)**	**<0.001**	1.01 (0.80-1.27)	0.94	**0.67 (0.51-0.89)**	**0.005**

Table 3 continued……

Sociodemographic variables	Insufficient Fruits/veg consumption				Insufficient Physical activity			
	Men		Women		Men		Women	
	Odds Ratio (95% CI)	p-value*	Odds Ratio (95% CI)	p-value*	Odds Ratio (95% CI)	p-value*	Odds Ratio (95% CI)	p-value*
Age Group								
Below 35 years	--	--	--	--	--	--	--	--
35-59 years	0.70 (0.48-1.02)	0.06	0.92 (0.69-1.24)	0.61	1.01 (0.72-1.42)	0.91	0.95 (0.73-1.25)	0.74
60 years and above	0.75 (0.44-1.28)	0.29	1.51 (0.89-2.53)	0.12	**2.04 (1.30-3.19)**	**<0.001**	**2.26 (1.54-3.31)**	**<0.001**
Ethnicity								
Dalits	--	--	--	--	--	--	--	--
Disadvantaged janjati	0.94 (0.46-1.92)	0.87	1.20 (0.69-2.10)	0.51	1.68 (0.95-2.95)	0.06	1.12 (0.74-1.69)	0.58
Religious minorities	**0.09 (0.02-0.35)**	**<0.001**	0.39 (0.15-1.03)	0.06	2.11 (0.74-5.98)	0.15	1.36 (0.59-3.12)	0.46
Advantaged janajati	0.82 (0.40-1.69)	0.59	**0.47 (0.28-0.79)**	**0.004**	1.75 (0.93-3.26)	0.08	1.02 (0.63-1.64)	0.94
Upper cast	0.65 (0.35-1.21)	0.17	**0.56 (0.36-0.88)**	**0.01**	1.56 (0.90-2.67)	0.10	1.00 (0.68-1.45)	0.99
Educational attainment								
Primary incomplete	--	--	--	--	--	--	--	--
Primary complete	**0.42 (0.26-0.66)**	**<0.001**	0.76 (0.53-1.10)	0.15	1.27 (0.85-1.88)	0.23	0.90 (0.65-1.26)	0.56
Secondary	**0.48 (0.31-0.75)**	**0.002**	**0.59 (0.41-0.85)**	**0.004**	1.21 (0.82-1.78)	0.33	0.89 (0.64-1.23)	0.49
University	**0.28 (0.13-0.59)**	**<0.001**	0.85 (0.34-2.03)	0.83	1.67 (0.85-3.28)	0.13	0.82 (0.38-1.78)	0.62
Location								
Rural location	--	--	--	--	--	--	--	--
Urban location	1.28 (0.65-2.50)	0.46	1.07 (0.56-2.03)	0.96	**1.76 (1.14-2.73)**	**0.01**	**2.08 (1.35-3.20)**	**<0.001**
Wealth Index								
Lower wealth index	--	--	--	--	--	--	--	--
Middle wealth index	1.40 (0.89-2.19)	0.14	1.11 (0.78-1.57)	0.55	0.75 (0.50-1.13)	0.21	1.08 (0.80-1.47)	0.59
Upper wealth index	0.91 (0.65-1.28)	0.59	1.27 (0.96-1.68)	0.09	0.98 (0.72-1.34)	0.93	0.96 (0.75-1.23)	0.77

* p-value of the General Wald test

Table 4: Age effects on the relationship between four behavioral and four biological risk factors - stratified by sex
(Results from multiple mixed logistic regression models with interaction of age and health behaviour)

Predicting variables (Adjusted for sociodemographic variables)	**Hypertension (Women)**		**Hypertension (Men)**		**Diabetes (Women)**		**Diabetes (Men)**	
	AOR (95% CI)	**p-value[#]**	**AOR (95% CI)**	**p-value[#]**	**AOR (95% CI)**	**p-value[#]**	**AOR (95% CI)**	**p-value[#]**
Daily Smoking								
Daily smokers	0.93 (0.35-2.43)	0.88	1.00 (0.62-1.63)	0.97	2.41 (0.28-2.04)	0.88	1.17 (0.41-3.34)	0.75
Age (35-59 years)*	**2.95 (2.35-3.69)**	**<0.001**	**2.41 (1.79-3.26)**	**<0.001**	**4.15 (2.56-6.73)**	**<0.001**	**2.64 (1.41-4.97)**	**<0.001**
Age (60 years and above)*	**6.10 (4.38-8.50)**	**<0.001**	**4.21 (2.80-6.34)**	**<0.001**	**4.18 (2.10-8.32)**	**<0.001**	**3.56 (1.64-7.72)**	**0.001**
Daily smoking: age 35-59 years	0.65 (0.23-1.79)	0.4	0.88 (0.50-1.56)	0.67	4.13 (0.04-3.79)	0.43	1.00 (0.31-3.22)	0.99
Daily smoking: age 60+ years	0.85 (0.29-2.50)	0.7	0.88 (0.43-1.80)	0.74	3.43 (0.03-3.65)	0.37	0.75 (0.18-3.16)	0.69
Consumption of Alcohol in 12 months								
Alcohol consumption in last 12 months	**1.82 (1.09-3.04)**	**<0.001**	1.48 (0.98-2.23)	0.06	2.88 (0.82-10.04)	0.09	1.01 (0.40-2.53)	0.97
Age (35-59 years)*	**2.75 (2.17-3.48)**	**<0.001**	**2.33 (1.61-3.36)**	**<0.001**	**4.17 (2.45-7.10)**	**<0.001**	**3.14 (1.54-6.38)**	**0.001**
Age (60 years and above)*	**6.47 (4.66-9.00)**	**<0.001**	**4.97 (3.16-7.79)**	**<0.001**	**4.60 (2.25-9.42)**	**<0.001**	**4.01 (1.76-9.09)**	**<0.001**
Alcohol in 12 months: age 35-59 years	0.86 (0.48-1.53)	0.62	1.05 (0.64-1.70)	0.83	0.59 (0.15-2.30)	0.19	0.65 (0.23-1.84)	0.42
Alcohol in 12 months: age 60+ years	**0.46 (0.21-0.98)**	**0.04**	0.69 (0.36-1.33)	0.27	0.21 (0.03-1.41)	0.11	0.46 (0.11-1.88)	0.28
Insufficient Fruits and Veg Consumption								
Insufficient fruits and veg consumption	0.99 (0.60-1.62)	0.98	0.95 (0.55-1.63)	0.86	0.90 (0.31-2.56)	0.84	1.37 (0.40-4.75)	0.61
Age (35-59 years)*	**2.48 (1.42-4.35)**	**<0.001**	**2.69 (1.51-4.78)**	**<0.001**	**7.04 (2.41-20.53)**	**0.003**	**4.41 (1.28-15.12)**	**0.01**
Age (60 years and above)*	**5.97 (2.54-14.04)**	**<0.001**	**2.71 (1.22-6.00)**	**0.01**	1.00 (0.10-9.15)	0.99	**5.28 (1.15-24.16)**	**0.03**
Insufficient fruits and veg: age 35-59 years	1.15 (0.63-2.07)	0.64	0.84 (0.45-1.56)	0.58	0.50(0.16-1.57)	0.16	0.53 (0.14-2.01)	0.35
Insufficient fruits and veg: age 60+ years	9.96 (0.40-2.42)	0.99	1.61 (0.69-3.79)	0.26	4.25 (0.43-4.12)	0.21	0.58 (0.11-3.01)	0.51
Insufficient Physical Activity								
Insufficient Physical Activity	0.89 (0.54-1.47)	0.65	0.55 (0.29-1.03)	0.06	1.72 (0.70-4.19)	0.73	0.38 (0.08-1.86)	0.23
Age (35-59 years)*	**2.73 (2.16-3.44)**	**<0.001**	**2.24 (1.69-2.96)**	**<0.001**	**4.15 (2.47-6.97)**	**<0.001**	**2.13 (1.20-3.79)**	**0.009**
Age (60 years and above)*	**5.60 (4.02-7.81)**	**<0.001**	**3.93 (2.68-5.77)**	**<0.001**	**4.73 (2.35-9.51)**	**<0.001**	**3.07 (1.49-6.31)**	**0.002**
Insufficient Physical activity: age 35-59 years	1.22 (0.68-2.20)	0.49	1.46 (0.70-3.04)	0.30	0.82 (0.29-2.28)	0.70	4.10 (0.76-22.17)	0.10
Insufficient Physical activity: age 60+ years	1.33 (0.65-2.72)	0.42	1.50 (0.64-3.53)	0.34	0.30 (0.07-1.28)	0.10	1.95 (0.28-13.20)	0.49

AOR: Adjusted Odds Ratio (adjusted for sociodemographic variables: ethnicity, occupation, education, wealth index, location)

* Reference age group: 15-35 years

[#] p-value of the General Wald test

Table 4 continued…….

Predicting Variables (adjusted for sociodemographic variables)	Overweight/obesity (Women)		Overweight/obesity (Men)		Hyperlipidemia (Women)		Hyperlipidemia (Men)	
	AOR (95% CI)	p-value[#]	AOR (95% CI)	p-value[#]	AOR (95% CI)	p-value[#]	AOR (95% CI)	p-value[#]
Daily Smoking								
Daily smokers	0.74 (0.28-1.91)	0.54	1.29 (0.75-2.19)	0.34	1.58 (0.50-4.92)	0.42	1.11 (0.46-2.68)	0.80
Age (35-59 years)*	**1.63 (1.33-2.00)**	**<0.001**	**2.18 (1.56-3.05)**	**<0.001**	**2.68 (2.01-3.58)**	**<0.001**	**2.01 (1.21-3.36)**	**0.007**
Age (60 years and above)*	1.17 (0.82-1.66)	0.37	1.49 (0.93-2.38)	0.09	**4.56 (3.05-6.81)**	**<0.001**	1.65 (0.82-3.36)	0.15
Daily smoking: age 35-59 years	0.58 (0.21-1.60)	0.29	0.67 (0.36-1.26)	0.22	0.53 (0.16-1.77)	0.30	0.73 (0.27-2.00)	0.55
Daily smoking: age >= 60 years	0.35 (0.10-1.19)	0.09	0.68 (0.29-1.60)	0.38	0.83 (0.23-2.93)	0.77	0.77 (0.21-2.76)	0.68
Consumption of Alcohol in 12 months								
Alcohol consumption in last 12 months	**2.36 (1.50-3.71)**	**<0.001**	1.21 (0.76-1.92)	0.40	**2.13 (1.11-4.09)**	**0.02**	1.85 (0.88-3.88)	0.10
Age (35-59 years)*	**1.63 (1.32-2.01)**	**<0.001**	**2.17 (1.45-3.25)**	**<0.001**	**2.72 (2.02-3.65)**	**<0.001**	**2.39 (1.23-4.64)**	**0.009**
Age (60 years and above)*	1.13 (0.79-1.61)	0.47	1.28 (0.75-2.16)	0.35	**5.49 (3.68-8.20)**	**<0.001**	**2.42 (1.10-5.30)**	**0.02**
Alcohol in 12 months: age 35-59 years	**0.48 (0.28-0.82)**	**0.04**	0.84 (0.49-1.45)	0.54	0.59 (0.28-1.22)	0.15	0.63 (0.27-1.47)	0.29
Alcohol in 12 months: age >= 60 years	**0.26 (0.11-0.61)**	**0.001**	1.29 (0.60-2.76)	0.50	**0.37 (0.15-0.94)**	**0.03**	0.34 (0.10-1.15)	0.08
Insufficient Fruits and Veg Consumption								
Insufficient fruits and veg consumption	0.69 (0.47-1.02)	0.06	1.13 (0.61-2.09)	0.68	1.34 (0.68-2.63)	0.39	0.60 (0.25-1.44)	0.25
Age (35-59 years)*	1.00 (0.62-1.62)	0.11	**2.51 (1.30-4.83)**	**0.005**	**4.36 (2.10-9.08)**	**<0.001**	1.66 (0.68-4.02)	0.25
Age (60 years and above)*	0.97 (0.40-2.36)	0.95	2.03 (0.80-5.13)	0.13	**3.42 (1.08-10.84)**	**0.03**	1.11 (0.29-4.25)	0.86
Insufficient fruits and veg: age 35-59 years	1.61 (0.97-2.67)	0.06	0.74 (0.36-1.50)	0.41	0.54(0.25-1.18)	0.12	1.13 (0.42-3.03)	0.79
Insufficient fruits and veg: age >= 60 years	0.98 (0.39-2.49)	0.97	0.60 (0.22-1.64)	0.32	1.42(0.43-4.66)	0.56	1.47 (0.34-6.29)	0.59
Insufficient Physical Activity								
Insufficient Physical Activity	1.04 (0.70-1.54)	0.81	1.36 (0.76-2.46)	0.29	0.75(0.39-1.44)	0.39	0.42 (0.11-1.51)	0.18
Age (35-59 years)*	**1.54 (1.25-1.90)**	**<0.001**	**2.04 (1.48-2.80)**	**<0.001**	**2.38 (1.77-3.18)**	**<0.001**	**1.79 (1.11-2.88)**	**0.01**
Age (60 years and above)*	0.91 (0.63-1.31)	0.61	1.42 (0.91-2.32)	0.11	**4.06 (2.70-6.09)**	**<0.001**	1.33 (0.68-2.58)	0.39
Insufficient Physical activity: age 35-59 years	0.86 (0.52-1.44)	0.58	0.82 (0.40-1.67)	0.58	1.86 (0.88-3.92)	0.09	1.61 (0.39-6.68)	0.50
Insufficient Physical activity: age >= 60 years	1.14 (0.55-2.35)	0.71	0.70 (0.28-1.78)	0.46	2.36 (0.99-5.6)	0.05	2.80 (0.57-13.78)	0.20

AOR: Adjusted Odds Ratio from multiple mixed logistic regression adjusted for sociodemographic variables: ethnicity, occupation, education, wealth index, location

* Reference age group: 15-35 years

[#] p-value of the General Wald te

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6. Complete list of publications

SN	Title of article (with link)	Name of journal	Year	Contribution
1	Effects of age on NCDs risk factors among Nepalese adult population. (*10.1371/journal.pone.0281028)*	PLoS one	2023	Lead author
2	Utilization of adolescent friendly health services and its associated factors among higher secondary students in mid-western Himalayan mountainous district of Nepal (*Doi.org/10.1371/journal.pgph.0001616)*	PLoS Global Public Health	2023	Co-author
3	Health sector readiness for the prevention and control of non-communicable diseases: A multi-method qualitative assessment in Nepal *(DOI: 10.1371/journal.pone.0272361)*	PLoS one	2022	Lead author
4	Climate change impacts on the health of South Asian children and women subpopulations - A scoping review *(DOI: 10.1016/j.heliyon.2022.e10811)*	Heliyon	2022	Co-author
5	Maintenance versus replacement of medical equipment: a cost-minimization analysis among district hospitals in Nepal *(DOI: 10.1186/s12913-022-08392-6)*	BMC health service research	2022	Co-author
6	Human Resources for Cardiovascular Disease Management in Nepal: A National Need Assessment Kathmandu University Medical Journal 19(75):3-10	Kathmandu University Medical Journal	2022	Co-author
7	Health system gaps in cardiovascular disease prevention and management in Nepal (DOI: 10.1186/s12913-021-06681-0)	BMC health service research	2022	Co-author
8	Proceedings from the CIH-LMU 2021 Symposium: "Global Health Perspectives: Climate Change & Migration" (DOI: 10.1186/s12919-021-00225-4)	BMC proceedings	2021	Co-author
9	Planning of births and childhood undernutrition in Nepal: evidence from a 2016 national survey (DOI: 10.1186/s12889-020-09915-8)	BMC Public health	2021	Co-author
10	Cardiovascular disease trends in Nepal – An analysis of global burden of disease data 2017 (DOI: 10.1016/j.ijcha.2020.100602)	IJC heart and Vasculature	2020	Co-author
11	Planning of births and childhood undernutrition in Nepal: evidence from a 2016 national survey (DOI: 10.1186/s12889-020-09915-8)	BMC Public health	2020	Co-author
12	Psychological Distress Among The AdultSurvivors of Kathmandu Valley From Nepal's 2015 Earthquake (DOI: 10.5350/Sleep.Hypn.2017.19.0139)	Sleep and Hypnosis; A journal of clinical neurosciences and psychopathology	2018	Last author
13	What factors influence the choice of urban or rural location for future practice of Nepalese medical students? A cross-sectional descriptive study (DOI: 10.1186/s12960-015-0084-5)	BMC Human Resources for Health	2015	Lead author
14	Intended Location of Future Career Practice among Graduating Medical Students: Perspective from Social Cognitive Career Theory in Nepal [Journal of Nepal Health Research Council 11(25):229-263]	Journal of Nepal Health Research Council	2015	Lead author