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Developing a Conceptual Framework with a Life Course Approach to

Support Universal Health Coverage Monitoring Systems

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20 **Introduction**

21 The world population as a whole is expected to age significantly in the next 30 years [1, 2]. Specifically,

22 the populations of low- and middle-income countries (LMICs), which are relatively young currently,

23 will age remarkably by 2050 [3]. For example, China in 2050 will have 348.8 million older people

24 (aged 60 and above), which is equal to the total projected populations of Japan, Egypt, Germany, and

25 Australia combined. In addition, over the same time, at least 13 LMICs in Asia are projected to

26 experience a quadrupling of their aged 80 and over population [4].

27 In general, aging populations are the result of declining fertility and increasing

28 longevity. Longer lives with good health are advantageous for both individuals and societies. Older

29 people will have more years to engage in activities they did not have the chance to do during their

30 earlier years, such as hobbies. Society also will be affected positively by having older people act as

31 mentors or caregivers. Conversely, declining health also affects older people and societies adversely

32 [5-7].

33 Recent research has found older people in LMICs are at risk of suffering from

34 emerging noncommunicable diseases that lead to chronic diseases and disabilities. In addition,

35 communicable diseases are a constant, and potential pandemics are foreseeable [8-10]. These

36 conditions will complicate health problems and overburden health systems [4, 11]. Previous research

37 has also alerted about how rapidly aging populations in LMICs may impact the efforts of those

38 countries to achieve universal health coverage (UHC), which is one target of the Sustainable

39 Development Goals [10-13]. However, many LMICs are struggling to measure progress towards UHC

40 with consideration of epidemiological and demographic changes [10, 14].

41 Several attempts to monitor recent progress toward UHC have been made, including

42 the Global Monitoring Report, which examined UHC progress in 132 countries [15-20]. Global

43 monitoring evaluates two broad components: service coverage and financial protection [16, 21].

44 Although both components are essential to monitoring UHC progress [22], in the present study we

45 focus on improvements of service coverage monitoring. Age- and disease-specific indicators within

46 global monitoring systems, however, are dominated by maternal, child, and infectious disease

47 indicators [23, 24], making them ineffective at monitoring the progress of service coverage in LMICs

48 with aging populations because of a failure to adequately consider the demographic and

49 epidemiological profiles [7, 14]. Good monitoring of service coverage is essential for understanding

50 the latest national situation and would allow governments to evaluate their progress towards UHC and

51 make proper adjustments [25, 26].

52   To facilitate the monitoring of service coverage in LMICs with aging populations, we

53 proposed a life course approach. Life course approaches promote maximizing an individual's

54 functional ability throughout the lifespan, rather than age- or disease-based examinations, to achieve

55 healthy aging by considering the long-term effects of both current health status and developmental

56 processes such as socioeconomic and environmental exposures [27-30]. Thus, a life course approach

57 could support integrating service coverage monitoring by horizontally including all ages while

58 considering holistic domains, i.e. health, social, and environment. Moreover, a life course approach

59 helps LMICs take care of their younger populations while at the same time preparing for aging

60 populations by examining earlier life conditions to prevent later life risks [23, 29].

61   Previous studies had adapted the life course approach to health [23, 27, 28] and to UHC

62 monitoring [25, 29]. However, to our knowledge, there is no framework to help governments respond

63 to demographic and epidemiological changes in service coverage monitoring, particularly with regards

64 to aging populations in LMICs. Using the service coverage index [20], the present study aimed to (1)

65 develop a conceptual framework for a life course approach toward service coverage monitoring and

66 (2) analyse current scientific literature on the application of a life course approach to health policies,

67 services, and interventions to identify possible areas for future research on service coverage monitoring.

68 Our findings could support national and international efforts to monitor key policies, services, and

69 interventions as part of service coverage to ensure the well-being of all populations in LMICs.

70 **Methods**

71 For this study, we used a proposed conceptual framework to guide our scoping review of the literature.

72 We consulted our initial draft to experts from Indonesia and Thailand. The process took place between

73 April 2019 until July 2020. Our main team consisted of diverse nationalities including Japan, France,

74 Thailand, and Indonesia and expertise in geriatrics, community health, and health financing. We

75 conducted the main investigation of the conceptual framework to facilitate the literature review and

76 later carried a consultation aobout the initial draft with experts from Indonesia and Thailand about our

77 initial draft from April 2019 to July 2020 through e-mail. Experts were identified by the author of a

78 related article about UHC in LMICs.

79 Conceptual framework

80 We developed a conceptual framework to combine existing concepts and to present how the life course

81 approach may be helpful to respond to demographic and epidemiological changes. We referred to a

82 previous article about conceptual framework developments in general [31] and simultaneously referred

83 to developments in life course approaches. First we conducted a literature search with the following

84 combination of keywords: "life course approach", "framework", "health", and "universal health

85 coverage", and did a snowball sampling of the related references (Table 2). Second, we included six

86 previous studies that describe a life course approach in health or UHC monitoring [23, 25, 28, 29, 32].

87 Third, we reviewed five previous articles to discover similar or contradictory concepts among articles.

88 Fourth, we grouped together concepts with similarities into one new concept. Finally, we synthesized

89 our new concept narratively so that the conceptual framework could be understood.

90   We used the conceptual framework to guide the literature review and interpret the

91   results. Moreover, we pointed out gaps between the literature review regarding the conceptual

92   framework and recent global monitoring.

93   Literature review

94   A literature review was carried out using the scoping review method. The scoping review is a suitable

95   method to achieve our research objectives, because the body of literature about

96   policies/services/interventions for life course approaches to healthy aging is limited, complex, and

97   diverse. A scoping review is useful for assessing the extent, range, and nature of research activity to

98   map fields of study as well to identify knowledge gaps in a given topic [33, 34]. A scoping review is

99   also important for advancing intensive knowledge synthesis, particularly for increasing the efficiency

100   and quality of future evidence synthesis and providing insights for subsequent research directions [35].

101   The aim of the present scoping review is to systematically examine and summarize the

102   nature and knowledge gaps of existing data about policies, services, interventions, and related research

103   aimed at improving the health and function of older people based on life course approaches or

104   frameworks. In detail, the scoping review consisted of several stages: a literature search, study

105   selection, data charting and summarizing, and data synthesis, as recommended by previous studies [33,

106   34, 36].

107   Regarding the literature search, the papers were retrieved from online databases that are

108   representative of health, social, and economic sciences. The databases were PubMed, Web of Science,

109   and Google Scholar. Literature searching was accomplished using a combination of keywords related

110   to "life course", "aging", "policy/service/intervention", and "function/disability". Details of the search

111   strategy are described below. We used EndNote X9 application to remove duplicates prior to a manual

112   de-duplication process.

113   During the study selection, we screened the literature by executing a title-abstract

114   screening and then full-text screening. We invited several reviewers whom are physical therapists with

115   expertise mainly in the health of geriatrics and/or maternity and early life, of adolescents, of young

116   adults, and of working-age adults. Prior to the title-abstract screening by five reviewers (A, B, C, D,

117   E), a trial was done by C with a WHO Technical Officer as the evaluator. This trial was important to

118   assure the inclusion and exclusion criteria were applicable and explicit. Later, the result of the trial

119   was discussed among the five reviewers to ensure the team shared common understanding when

120   deciding whether an article should be included or excluded. After adjustments to several reviewers'

121   suggestions and revisions, the final inclusion and exclusion criteria were decided (Table 1). Finally,

122   the reviewers were gathered for a one-day training. They examined the included articles individually.

123   However, group discussions were held during and after the screening process to evaluate each

124   member's conclusion, particularly when there was uncertainty about the selected papers.

125   Consecutively, we proceeded to a full-text screening done by eight reviewers (B, D, E,

126   F, G, H, I, K). We asked more reviewers for the full-text screening to fit in the time schedule. Moreover,

127   different reviewers provided confirmation of the included studies, because they screened the articles

128   randomly and made judgement about whether to include the study or not. For reviewers B, D, and E,

129   who also did the title-abstract screening, they worked on articles other than their title-abstract screened

130   articles. All reviewers were asked to make judgement about which article should be included and to

131   fill the data extraction form to gain necessary data for the data charting and summarizing process. The

132   trial of the data extraction form had been performed by C with the WHO Technical Officer as the

133   evaluator. Following the trial process, the summary was discussed among the eight reviewers to ensure

134   the team shared the same understanding in deciding whether an article should be included or excluded

135   and how to fill the form. After adjustments to several reviewers' suggestions, reviewer C completed

136   the final version of the data extraction form. Finally, we asked the reviewers to follow a one-day

137   training prior to the full-text screening. The research team and reviewers conducted a group discussion

138 following the full-text screening to evaluate each member's conclusion, particularly when there was

139 uncertainty about selected papers.

140   The reviewers were requested to do the data extraction using the original extraction

141 form developed by previous studies [35, 37-39] and the present study objective. The reviewers

142 appraised the study's methodology using Mixed Methods Appraisal Tool 2018 (MMAT 2018) [40-

143 44], which helped us determine the study's quality even though the scoping review did not obligate

144 this process. Moreover, this kind of appraisal tool facilitated the reviewers to examine a broad range

145 of the study design, because the present study did not set exclusion criteria for a certain study design.

146 In brief, MMAT 2018 was used to appraise empirical studies only and could not be used to assess non-

147 empirical articles such as review or theoretical articles. MMAT 2018 covered five study designs:

148 qualitative, quantitative randomized controlled trials, quantitative non-randomized, quantitative

149 descriptive, and mixed-methods. Reviewers were to choose the appropriate category of studies,

150 because each study design has different quality criteria. The response to each quality criterion was a

151 point (1) for the presence, null (0) for the absence, or not applicable (NA) if the criterion did not match

152 the article's study design. We did not set a high or low quality as final judgement, since the tool's

153 manual discouraged this approach. Finally, the reviewers decided whether the study was included or

154 not for further analysis using the inclusion and exclusion criteria.

155   Finally, we did data charting and data summarizing using the extraction form, in which

156 information from selected papers was extracted and subsequently composed into a summary. Two

157 reviewers (B and C) re-checked the form after all reviewers completed it to make sure the included

158 paper satisfied the inclusion-exclusion criteria and to confirm missing data and questionable content.

159 Results from the data extraction are explained and synthesised narratively in the Results and

160 Discussion sections.

161 Search strategy

162 A search for peer-reviewed journals was executed using academic databases (PubMed and Web of

163 Science) and grey literature (Google Scholar, snowball sampling the references, and experts'

164 recommendation) between June 2019 and December 2019. We considered Google Scholar as

165 necessary, because we aimed to expand the search to wider and more general sources. We did snowball

166 sampling by hand-searching the papers and citations that were assumed missed during the electronic

167 searches. Snowball sampling also included websites of international organizations recommended by

168 known experts in order to identify documents that focus on life-course approaches and/or UHC

169 frameworks.

170 Table 1. Inclusion and exclusion criteria of the scoping review

Inclusion criteria	
1.	Existing papers with qualitative/quantitative analysis of the effect of a policy/service/intervention based on a life-course approach to achieve healthy aging populations (healthy aging here refers to any improved elderly health outcome)
2.	Existing qualitative/quantitative papers on regional policies, programs, or interventions using life-course approaches to achieve healthy aging communities
3.	Existing quantitative studies on life-course concepts for particular life aspects (i.e., health, social, etc.) with healthy aging or improving older (50 years or older) people's health as an outcome
4.	Existing quantitative studies focusing only on older people so long as they examine the effects of a life course factor on older people's health as a future outcome. In other words, studies that look at the impact of an older person's recent health on health outcomes over a short time (1-5 years)
5.	Existing studies that are cross-sectional in design but also mention the impact of life-course factors and healthy aging as an outcome
6.	Papers written in English
7.	Studies published from 2009 to present (2019)
8.	Studies that consider general populations or general diseases (communicable and noncommunicable diseases)
Exclusion criteria	
1.	Theoretical papers that discuss life course approaches and healthy aging without any empirical analysis
2.	Reports on current problems without consideration of later life effects on older people's health
3.	Articles that mentioned "life course"/ "healthy aging" less than five times
4.	Articles in which the application of a life course as an approach or healthy aging as a goal in policy/program/intervention was not clear
5.	Interventions or experiments on non-humans
6.	Incomplete or inaccessible papers such as editorials, comments, databases, etc.
7.	Reports on life-course measurements or analysis techniques

171

172   Table 2. Search terms

PubMed
Word combination: ("life course" OR "early life") (older OR elder* OR senior OR geriatric*) (intervention OR policy OR program OR action OR plan OR agenda OR "health service for the aged" OR "health service") ("healthy aging" OR "functional ability" OR "activit* of daily living" OR "limitat* of activity" OR dysfunction* OR disabilit*)
Special database option: Only research on humans Language English Timespan 2009-2019
Web of Science
Word combination: TS=(intervention OR policy OR program OR action OR plan OR agenda OR "health service*" OR "social service*" NEAR/1 ("life course" OR "later life" OR "healthy aging" OR "healthy age*")) AND TS=("life course" OR "life course NEAR/0 (approach* OR perspective* OR stud* OR theory*)") AND TS=("functional ability" OR "activit* of daily living" OR "limitat* of activity" OR dysfunction* OR disabilit*) AND TS=("older people" OR elder* OR age* OR agi* OR senior OR geriatric*)
Special database option: Language English Articles only Timespan 2009-2019
Google Scholar
Word combination: policy intervention "life course" "healthy aging" "health service" "social service" "functional ability" OR action OR program OR agenda OR "activity of daily living" OR "limitation of activity" OR dysfunction OR disability OR older "life course"
Special database option: Language English

Articles only
Timespan 2009-2019
Without patents and citations
Other websites
Asian Development Bank
World Bank
WHO
United Nation Development Programme

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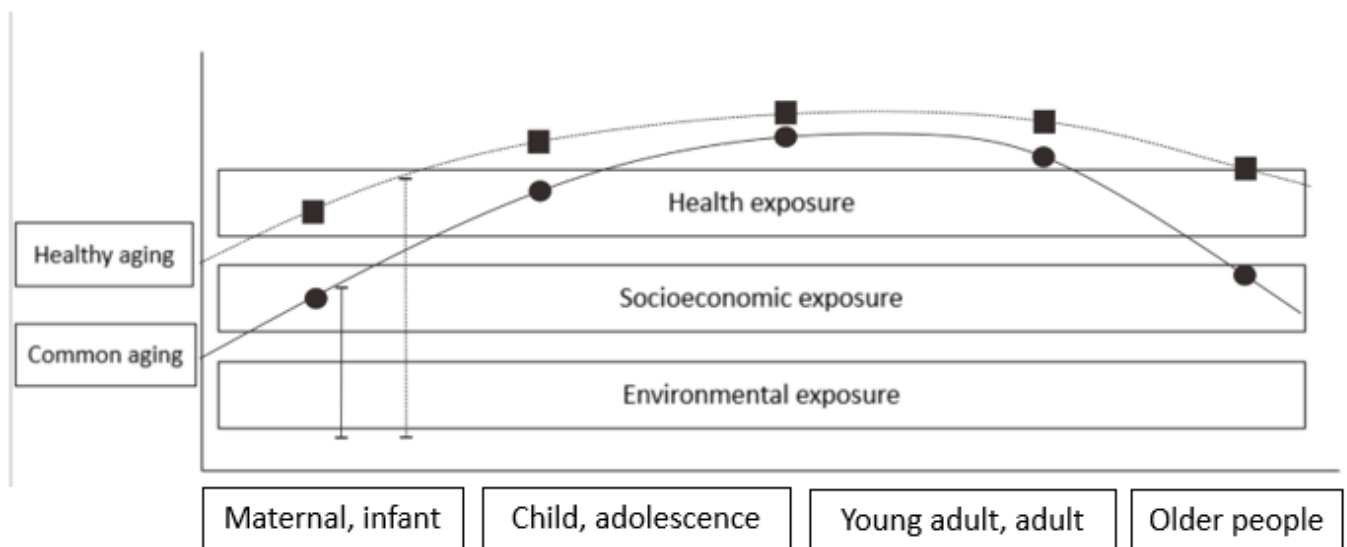
Results

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175   Conceptual Framework

176   The first article reviewed [25] demonstrated a framework that conceptualized recent global monitoring

177   through the life course. The framework consisted of financial risk protection; health impact through

178   the life course; health service coverage; health system resources, capacity, and performance; and social

179   determinants of health. However, there was no further explanation provided. The second article [23]

180   presented a framework of how a life course links to health and the implication of its implementation.

181   The framework was built from several components such as the life stage, individual health outcomes,

182   social and environmental determinants of health, and principles in practice for the realization of rights.

183   The framework of the life course approach to health emphasized functional ability as the main outcome.

184   Functional ability was represented as individual or population well-being by considering internal and

185   external stimuli. The third article [28] demonstrated several conceptual models of the life course

186   approach to health; they were the critical period model, cumulative model, trigger model and, the latest

187   model, the pathway model. In general, all models considered a person's lifespan, exposure, later life

188   health outcomes, and the role of other factors outside health factors such as socioeconomic status and

189   environment. The fourth article [29] presented a framework of the trajectory of health and well-being

190   across the life course by considering the life stage, accumulating damage across the lifespan, resilience,

191   and peak capacity. It emphasized the maintenance of peak capacity and minimization of early decline.

192   The fifth article [32] proposed a life course health development framework. The framework was more

193 complex compared to other frameworks and used an input-process-output model. It consisted of four

194 related principles: the multiple contexts of health development, such as physical, social, family, and

195 other environments; the design and process of health development; the mechanism responsible for

196 variations in health development trajectories; and the integration of multiple time frames across a

197 lifespan. The framework depicted how biological factors and environments transform a person's

198 functional ability across one's life course.

199   From the five frameworks, we saw consistency in several key words: life stage (from

200 birth until older age), functional ability, and factors (health, socioeconomic, and environment).

201 Predominantly, the five studies agreed that a healthy individual is not necessarily free from disease

202 and that we should examine the variation of their functional ability to perform daily life; every life

203 stage is affected by the past and will modify future conditions. The point, they continued, is to maintain

204 functional ability by considering health, socioeconomic, and environment factors. Those factors may

205 act either as risk factors or protective factors to later health outcomes (future). The current study

206 focused on aging populations, thus, we use the term healthy aging as a goal of later health outcomes.

207 Healthy aging is prescribed as the process of developing and maintaining the functional ability for the

208 well-being of older people [5].

209   We adapted the basic structure of the framework described by Kuruvilla et al. [23]. We

210 depicted health as an integrated system of multiple factors across a lifespan. We emphasized the

211 importance of maintaining functional ability in order to grow old with good well-being. With this

212 framework, we asserted that service coverage monitoring should consider health as an integrated

213 system of multiple factors and time frames instead of a fragmented assessment of disease-related

214 factors at one life stage. We then investigated how far this effort has been applied to

215 policies/services/interventions and related research based on life course approaches or frameworks at

216 improving the health and function of older people. Later, we explain how the literature review will

217 help us find the answer.

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Healthy aging

Common aging

Health exposure

Socioeconomic exposure

Environmental exposure

Maternal, infant | Child, adolescence | Young adult, adult | Older people

219

220 Figure 1. The conceptual framework of the life course approach to achieve healthy aging

221 The curved solid line depicts an individual's functional ability during common aging, and the curved

222 dotted line depicts the maintenance of functional ability. The vertical solid line depicts a comparison

223 of incomplete exposures (i.e., environmental and socioeconomic exposures only) for an individual,

224 while the vertical dotted line considers all exposures. We hypothesized that consideration of all

225 exposures more accurately represents the individual's functional ability across the lifespan. The black

226 circles and squares depict the integration and accumulative effect of each life stage, respectively.

227 Literature Review

228 Our study retrieved 514 articles. After removing duplicates and title/abstract screening, 175 full-text

229 articles were retrieved for further examination. Although our study objective aimed to investigate the

230 nature of existing policies/services/interventions on life course approaches to healthy aging, we

231 obtained a limited number of eligible articles. We expanded our inclusion criteria to epidemiological

232 research on the life course in healthy aging. To be easily understood and interpreted, we divided those

233 175 full-text articles into policy findings (n= 18) and epidemiological findings (n=157). After the full-

234   text screening, we included 84 articles: 9 articles on policy findings and 75 articles on epidemiology

235   findings (Figure 2).

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┌──────────────┐        ┌──────────────┐        ┌──────────────┐
│   PubMed     │        │   Web of     │        │   Google     │
│  (n= 201)    │        │   sciences   │        │   scholar    │
│              │        │  (n= 188)    │        │  (n= 125)    │
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       │                       │                       │
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│              Studies identified (n= 514)                       │
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                               │                │  Duplicates removed   │
                               │                │      (n= 33)          │
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                   ┌────────────────────┐
                   │  Studies screened  │
                   │     (n= 481)       │
                   └─────────┬──────────┘
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                             ├──────────► ┌────────────────────────────────┐
                             │            │ Studies excluded after title    │
                             │            │ and abstract screening          │
                             │            │ Not suitable content (n=306)    │
                             ▼            └────────────────────────────────┘
                 ┌──────────────────────┐
                 │ Full-text articles   │
                 │   assessed (n=175)   │
                 └──────────┬───────────┘
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                            │             │ Snowball searching and website  │
                            │             │           (n=0)                 │
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                            ├──────────► ┌────────────────────────────────┐
                            │            │ Full-text articles excluded     │
                            │            │          (n=91)                 │
                            ▼            └────────────────────────────────┘
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                 │ Studies included in  │
                 │   data extraction    │
                 │       (n=84)         │
                 └──────────────────────┘
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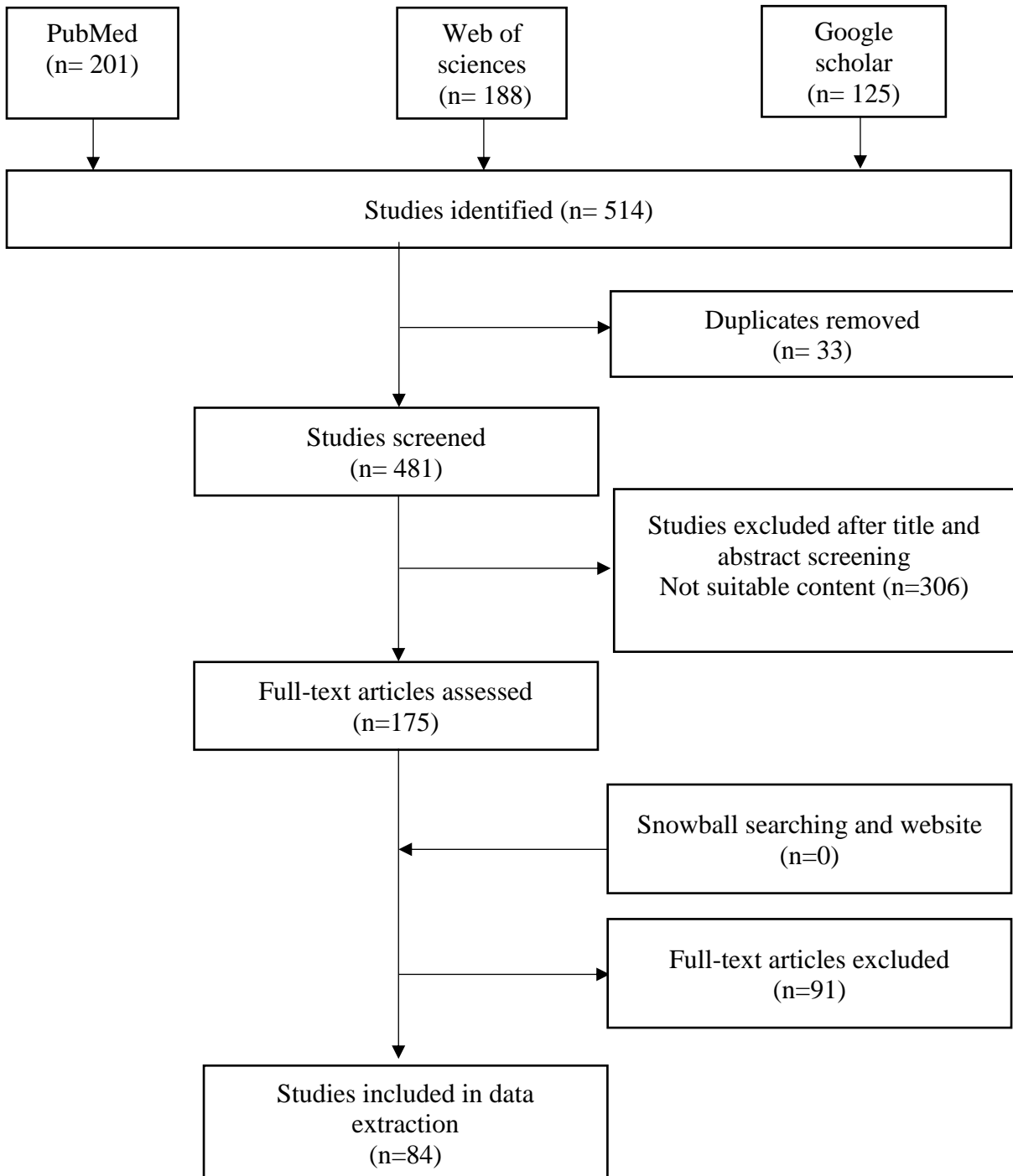
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254   Figure 2. The inclusion paper screening process

255   **Policy findings**

256   During the full-text screening, we examined 18 articles that discussed policies/services/interventions

257   in the life course for healthy aging. Nine articles in total were excluded. Six of these articles either

258   mentioned "life course"/ "healthy aging" less than five times or the application of a life course as an

259   approach and healthy aging as a goal in policy/service/intervention was not clear. The other three

260   articles were limited to addressing specific groups with certain conditions such as a dietician workforce,

261   older people with intellectual and developmental disabilities, and disabled older people. The nine

262   studies that we did include demonstrated policies/services/interventions with a life course approach

263   could enhance well-being at late life. All the included studies were delivered as a narrative review.

264   Unfortunately, MMAT 2018 could not assess the study presented as a review, therefore, we could not

265   assess the study's quality.

266   The majority of articles supported our conceptual framework by promoting life course approaches

267   implicitly. They did not directly introduce a life course approach, but they explained how each life

268   stage matters to healthy aging. Six articles suggested certain health services including integrated health

269   care (Table 3, row 1) [45], vaccines (Table 3, rows 5,6,7) [46-48], aging-friendly hospitals and health

270   services (Table 3, row 8) [49], and person centred trauma informed (PCTI)-based health services

271   (Table 3, row 9) [50]. In addition, four studies underlined the importance of socio-economic conditions

272   and environmental factors such as where the individual was born, lives, works, and aged along with

273   individual health (Table 3, rows 2,3,8,9) [49-52]. However, no study identified specific protective

274   exposures that might contribute to healthy aging. Furthermore, few of the studies comprehensively

275   explained a measurable standard to define whether one population or individual could be categorized

276   as healthy aging or not, and only a small number introduced quality of life (QoL), healthy life years,

277 life expectancy, frailty (Table 3, row 3) [52] and functional ability (Table 3, row 4) [23] as measurable

278 outcomes of healthy aging.

279 Furthermore, few studies mentioned policies in or related to LMICs (n=3) (Table 3, rows 1,4,5) [23,

280 45, 46] and only gave brief implementation of those policies in LIMCs setting. Only one of these

281 studies discussed strategies for a life course approach to immunization in LMICs (several countries in

282 Latin America) comprehensively [46]. Therefore, we have limited data to review feasible and

283 applicable policies in LMICs setting. Most studies discussed strategies or on-going programs from

284 high-income countries such as Taiwan (Table 3, rows 8) [49], the United States (Table 3, rows 2,6,9)

285 [47, 50, 51], and the European Union (Table 3, row 3) [52]. The last study did not mention any specific

286 geographical area [48].

287 The nine studies also tended to describe policies/services/interventions with older populations as a

288 target (Table 3, rows 1,5,7,8,9) [45, 46, 48-50] rather than extensively addressing each life stage (Table

289 3, rows 2,3,4,6) [23, 47, 51, 52].

290 Based on the focus of the present study, we analysed three main topics among the included policy-

291 related articles. First are articles that emphasized the importance of integrated health care in order to

292 achieve a heathy aging population (Table 3, rows 1-4) [23, 45, 51, 52]. "Integrated health care" has

293 several definitions. Two studies described integrated health care as delivering health care through

294 integrated up-to-down levels, such as the macro level (policy level) and micro level (clinical or

295 intervention level). Patient needs were placed at the centre of care, therefore, this model emphasized

296 integration at the level of clinical care (Table 3, rows 1, 4) [23, 45]. The two other studies described

297 integrated health care as a wide scope system that included the integration of common clinical care

298 and community-based health service [51, 52]. These studies also mentioned the importance of social

299 and environmental aspects. Moreover, each study uses different terms to address integrated health care

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300 such as "integrated health care" (Table 3, row 1) [45], "3.0 transformation" (Table 3, row 2) [51],

301 "culture of health" (Table 3; 3) [52], and "life course approach" (Table 3, row 4) [23].

302 Another topic of the policy findings is life course immunization [46-48]. All papers on this topic agreed

303 about the importance of expanding immunization programs from early life to later life including old

304 age. In line with this attitude, they were concerned about infectious illnesses that could be prevented

305 by currently available vaccines. Moreover, the articles also explained a link between infectious

306 diseases and increasing rates of morbidity and mortality. In sum, by expanding immunization across a

307 population's lifespan, it is possible to combat communicable and noncommunicable diseases within

308 aging populations.

309 The last two articles discuss age-friendly services (Table 3, row 8) [49] and trauma across one's

310 lifespan (Table 3, row 9) [50]. Age-friendly services underlined the importance for health care service

311 delivery to consider older populations' special needs and conditions. The paper also recommended that

312 health promotion and disease prevention be widely available to every individual at every age in

313 consideration of an age- and gender-appropriate basis. The article on trauma was a review outlining

314 several United States federal government programs that assist elderly who experienced or may

315 experience a traumatic event. The article defined trauma as a harmful experience either physically or

316 mentally that may have lasting adverse effects on the individual. Nonetheless, this review focused on

317 injury-based and interpersonal trauma.

318

319 Table 3. Characteristic of studies included on policy finding

	Title	Author	Year	LMICs	Population target	Discussed policy	Life course aspect included

1	Organizing integrated health-care services to meet older people's needs	de Carvalho et al.	2017	Yes	Older population	The importance of integrated health care to achieve better health outcomes among older people	The main aim of integrated care for older people is not to manage disease or prolong life but is instead to optimize older people's intrinsic capacity over their life course and, hence, ensure healthy aging.
2	Applying a 3.0 transformation framework to guide large-scale health system reform	Halfon et al.	2014	No	All ages	The 3.0 transformation framework (community integrated health system)	The 3.0 health system emphasizes not only activated patients but engaged communities and motivated populations focused on creating local conditions that support health over the life course.
1							

3	Creating a Culture of Health in planning and implementing innovative strategies addressing non-communicable chronic diseases	Tziraki-Segal et al.	2019	No	All ages	Initiating a Commission on Social Determinants of Health (CSDH) based on salutogenesis theory	Any effort to improve population health should be seen beyond the health care system and consider the condition where individuals are born, live, work and age.
4	A life-course approach to health: synergy with sustainable development goals	Kuruvilla et al.	2017	Yes	All ages	A paradigm shift in health and development policies and programmes with a life course approach to health	A life course approach to health optimizes the functional ability of individuals throughout life, enables well-being and realization of rights, and recognizes the critical interdependence of individual,

							intergenerational, social, environmental and temporal factors.
5	Latin American Adult Immunisation Advocacy Summit: Overcoming regional barriers to adult vaccination	Barratt, Mishra, and Acton	2018	Yes	Adult and older populations	Adult and elderly vaccinations	A life course approach rarely extends into middle and older ages, and most citizens are unaware of the benefits of vaccines against common, yet life-threatening infections, and the ultimate impact that vaccinations can have on healthy aging.
6	Challenges in adult vaccination	de Gomensoro, Giudice, and Doherty	2018	No	All ages	Vaccine policies for all age populations	The goals of life-course immunizations include more than simply preventing

							disease, but also include quality of life issues including productivity and independent living across an individual's lifespan.
7	Report of the ad-hoc consultation on aging and immunization for a future WHO research agenda online-course immunization	Thomas-Crusells, McElhaney, and Aguado	2012	No	Older populations	The report explained about the importance of vaccines against infectious diseases in the elderly	Since the immune system ages, trying to protect people later in life against certain pathogens may not be ideal. New vaccination schedules beginning from childhood and continue into adulthood (e.g., booster doses) and monitoring how immunity induced

							by these vaccines evolves as people age may be needed. This study bases its analysis on the concept of "life course vaccination".
8	Towards age-friendly hospitals and health services	Chiou and Chen	2009	No	Older populations	Age-friendly hospitals and health services based on WHO age-friendly principles. One approach has been done by Taiwan's framework of age-friendly hospitals	An age- and gender-appropriate needs assessment for health promotion and disease prevention is provided to every person at every age beginning from first contact. In this way, health promotion can be started as early as possible so that function can be maintained at the

							highest possible level, and every patient has the same rights.
9	Trauma Caused by Injury or Abuse in Late Life: Experiences, Impacts, and the Federal Response	Iyengar et al.	2019	No	Older populations	Represents a collaborative effort among federal departments with a stake in elder justice to identify gaps, make recommendations, and coordinate activities that serve older adults who experienced or may experience a traumatic event	Knowing that trauma can occur in anyone's life at any time throughout the life course and can have significant and lasting impacts on its victims and their families, it is essential that a broad spectrum of community-based organizations serving older adults have the competence and support to deliver PCTI (person-cantered trauma-

						informed)-based services.

320

Epidemiological finding

322 During the full-text screening, we categorized 157 articles into the epidemiological finding group.

323 Those papers discussed various exposures throughout the subject's lifespan that affect healthy aging

324 adversely or favourably. We excluded 82 articles because they were inaccessible (n=5), examined a

325 life course measurement/analysis technique (n=4), dissertations (n=5), addressed specific groups with

326 certain conditions (n=12) such as specific ethnic or specific morbidity groups, were gene/bio-

327 molecular studies (n=5), had no discussion about achieving healthy aging (n=9), had no discussion

328 about the life course (n=17), examined healthy aging in younger populations (n=8), or were qualitative

329 studies (n=17). We included articles that described older people's conditions as outcomes after

330 confirming they explained how exposures at earlier life stages have correlation or causal effects on

331 healthy aging. As a result, we included 75 eligible articles.

332 The study designs used by the included articles were varied: cross-sectional (n=14), longitudinal

333 (n=58), randomized-controlled (n=2), and exploratory (n=1). The study populations were mostly older

334 populations. However, some studies included a wide age range of populations in cross-sectional studies,

335 for example 16 to 99 years old [53]. In the longitudinal studies, the baseline age varied from early life

336 (i.e. 11 years old) or late adulthood (i.e. 45 years old) to the follow-up age at late life (i.e. 73 years old)

337 [54, 55]. The size of the populations also varied from 35 to 67 290 subjects.

338 The mean MMAT 2018 score of the 75 articles was 4.3 out of 5, which shows most of the papers

339 provide substantial and clear information regarding their study design and that the methodological

340 standard among and within the papers was met. Therefore, we could interpret and use the data for

341 further qualitative analysis. However, we could not qualify the study's quality into an ordinal standard,

342 such as low or high quality, as suggested by the MMAT 2018 guidelines.

343 Overall, few studies mentioned or reported LMICs (n=14), and most studies discussed or were

344 delivered from high-income countries (n=61).

345 Referring to our conceptual framework, we concluded that healthy aging can be achieved by

346 maximizing an individual's health, socio-economic, and environmental conditions. The included

347 studies mentioned those factors as exposures, covariates, or other variables except outcome. Due to

348 the heterogeneity of the data, we decided to analyse these factors as three big groups: health exposures,

349 socio-economic exposures, and environmental exposures. The majority of studies considered both

350 health and socio-economic aspects across a person's life (n=60). For example, one study considered

351 the education level and employment status (socio-economic exposures) as demographic characteristics

352 together with self-reported long-term illnesses (health exposure) [56]. On the other hand, few added

353 environmental aspects to the health and socioeconomic aspects (n=14). For example, one discussed

354 early life health, socio-economic conditions (health and socio-economic exposures), and late-life

355 residential location (environmental exposure) to examine correlations with late-life loneliness [57].

356 Considering our review objective about achieving healthy aging, we examined the outcomes that may

357 represent the healthy aging condition. However, the term "healthy aging" itself was broad and general

358 so that it was easily analysed and understood. Therefore, we divided the measurable outcomes from

359 the studies into six healthy aging domains: (i) general health, (ii) locomotor/physical capabilities, (iii)

360 cognitive functions, (iv) sensory functions, (v) psychological conditions, and (vi) vitality/metabolic

361 functions [6, 58, 59]. Several studies investigated more than one healthy aging domain. The list of

362 healthy aging domains, measurable outcomes, and number of papers are shown in Table 4.

363 Table 4. The summary of healthy aging domains

	Domain	Outcome	Number of papers
1.	General health	Self-rated health; Mortality; Later life health status; Life course trajectories (marriage, fertility, employment); Life expectancy; Life expectancy with disease; Successful aging indicator; Active aging; Active and healthy aging (AHA); Productive aging; Well-being; Allostatic load; Survival rate; Frailty risk; Health trajectories; Oral health; Health profile indicator; Healthcare utilization	n=29 (23+6)

2.	Locomotor/physical capabilities	Functional ability; Functional limitation; ADL; Grip strength; Physical activity; Physical function; Physical performance and strength; Physical fitness; Disability	n=26
3.	Cognitive functions	Cognitive performance; Cognitive function; Cognitive transition; Cognitive dysfunction; Brain structure; Fluid cognition; Dementia	n=13 (12+1)
4.	Sensory functions	NA	n=0
5.	Psychological conditions	Loneliness; Quality of Life (QoL); Depression; Anxiety; Mental health; Social support	n=11 (9+2)

6.	Vitality/metabolic functions	Noncommunicable diseases; Brain burden of cerebral small vessel disease (cSVD); Abdominal obesity; Diet behaviour; Pain	n=5

364

365 We describe the characteristics of the included studies in supplementary file 1.

366 **Discussion**

367 **Main findings**

368 From our scoping review, we have made a number of main findings: (i) articles about how life course

369 approaches can enhance older people's well-being were delivered either as reviews of

370 policies/services/interventions or epidemiological studies, (ii) both policy and epidemiological

371 findings supported our conceptual framework in that to achieve healthy aging, we should consider an

372 individual's health, socio-economic, and environmental conditions across his/her lifespan, (iii)

373 communicable and noncommunicable diseases might co-exist, (iv) policy and epidemiological

374 findings mostly addressed populations at early life (infant and children) or late life (older people) and

375 rarely mentioned mid-life (adolescence and working age), suggesting an imbalanced investigation of

376 the population life course, (v) there are six domains and various measurable outcomes that can used to

377 represent healthy aging, and (vi) there are few studies on policy implementation or epidemiological

378 studies on LMICs.

379 **Comparing recent service coverage monitoring systems**

27

380 From the conceptual framework and literature review, we recognized the well-being of aging

381 populations does not solely depend on the present situation and is influenced by the level of peak

382 function gained in earlier life [30]. The level of peak function reflects the accumulation of strengths

383 and deficits across the life course [5].Throughout our life cycle, there are critical periods and life

384 transitions. Critical periods are limited time windows when exposure may result in long-term effects

385 on the individual and are unlikely modifiable in later life [60]. For example, untreated or poorly treated

386 cataracts before an infant reaches his/her 18 month can alter the person's vision significantly, but not

387 so at older age. Moreover, the first decade of childhood is a critical period of neuronal vulnerability,

388 while late life has benefited by the maturity of neuronal connections [32].

389   Life transitions are a series of biological, psychological, and social transitions that

390 individuals experience during their lives. Those transitions could adversely or beneficially impact

391 future health, and their effects are relatively greater than other times. For example, entering or leaving

392 the workforce can lead to different stress levels, and how those levels are managed will drive the

393 individual to different functional trajectories. Both critical periods and life transitions happen multiple

394 times across a lifespan and account for important variations in aged people. Importantly, for some

395 interventions to be effective, they must be delivered at the early stages of life [32].

396   With this understanding, we note that interventions and monitoring throughout life

397 cannot be disregarded in efforts for the preservation of health among aging populations. To ensure

398 every person has access to decent health services, especially in aging population in LMICs, a

399 comprehensive monitoring system is needed [13, 61]. However, as we explain below, recent UHC is

400 not capturing or representing whole populations.

401   Recent UHC used monitoring indicators that are focused on early life (Table 4,

402 indicator numbers 2-4) and neglected indicators for adolescent, worker, and older populations.

403 Although the early life condition has an important effect on the later life condition [54, 55, 57, 62-68],

404 early adulthood is also important for later life outcomes in LMIC populations. Early adulthood

405 represents the critical time of the work environment related to a person's career development and

406 family formation [69]. Service coverage monitoring for older populations also deserves more attention

407 in UHC. Regarding the fact there is an increasing number of older people in LMICs, maintaining the

408 well-being of older people is crucial, because healthy older persons are a resource for society and the

409 economy. Aging populations that require more healthcare will be challenge for any nation [49].

410 As populations age, LMICs face the double burden of communicable diseases and

411 multiple noncommunicable diseases [23, 45, 51, 52]. One previous study even mentioned a triple

412 burden by including foreseeable pandemics [8]. As mentioned by one report, communicable and

413 noncommunicable diseases are interrelated [70]. Infection and deficiencies during a mother's

414 pregnancy, e.g. malaria and anaemia, may contribute to the risk of metabolic disease in the offspring's

415 adult life [71]. Furthermore, neglected or prolonged infectious diseases could be the origin of

416 noncommunicable diseases. For example, hepatitis B and C infections are strongly associated with

417 liver cancer, which has a high incidence in LMICs. Conversely, noncommunicable disease, such as

418 diabetes, might increase the risk of infectious disease like tuberculosis [72]. Finally, both types of

419 diseases could coexist in a person, complicating treatment.

420 From our point of view, recent service coverage monitoring already includes

421 communicable diseases (Table 4, indicator numbers 5-7) and noncommunicable diseases (Table 4,

422 indicator numbers 9-12). However, the complexity of health among aging populations in the future

423 cannot be conceptualized as disease-based only [7]. Health systems should recognize a person

424 functioning across the lifespan and the total sum of their health rather than discrete disease categories

425 [45, 73].

426 Lastly, our scoping review implied that healthy lives can be achieved if we consider

427 socioeconomic and environmental aspects. By tracking multiple aspects beyond health itself,

428   governments can evaluate, strengthen and promote future strategies for achieving healthy populations

429   [46]. For example, facilitating social programs (policy 3) or promoting age-friendly health settings

430   [49]. Socioeconomic and environmental factors, such as adverse childhood experiences (ACEs), early

431   life socioeconomic status, or area of residence, may have consequences along the individual's lifespan

432   [62, 74-78]. Thus, we concluded monitoring these factors is crucial for achieving healthy aging.

433   Recent UHC monitoring systems have investigated socioeconomic aspects only

434   limitedly as separate indicators for financial protection. However, those indicators only illustrated the

435   individual's recent condition and did not consider long-term or across lifespan aspects such as gender,

436   education, and race [56, 79-81]. Additionally, the indicators do not consider social aspects such as

437   social participation [82]. Lastly, environmental exposure has been included in recent UHC monitoring

438   indicators including living conditions (Table 4, indicator 8) and access to the health service (Table 4,

439   indicators 13 and 15).

440   Table 4. Tracer indicators of recent service coverage monitoring

	16 tracer indicators to monitor progress towards UHC on coverage of health services
1.	Family planning
2.	Pregnancy and delivery care
3.	Child immunization
4.	Child treatment
5.	Tuberculosis treatment
6.	HIV treatment
7.	Malaria prevention
8.	Water and sanitation
9.	Prevention of cardiovascular disease
10.	Management of diabetes

| 11. | Cancer detection and treatment |
12.	Tobacco control
13.	Hospital access
14.	Health worker density
15.	Access to essential medicine
16.	Health security

441

Future directions: a life course approach for service coverage implementation and monitoring

443   Based on recent findings, we identified key ways in which a life course approach can

444 improve service coverage implementation and monitoring. As suggested by the WHO 2019 Global

445 Monitoring Report on UHC [83], using these key points, we urge countries to design their healthcare

446 service and later make adjustments to the monitoring systems. The key points are (a) a healthcare

447 system that is integrated at the macro (i.e., policy or sector), meso (i.e., organizational or professional),

448 and micro (i.e., clinical or interventional) levels and simultaneously considers health, socioeconomic,

449 and environment factors, (b) a healthcare system that considers the unique features and needs of each

450 life stage and how each life stage is connected, and (c) a healthcare system that redefines health as a

451 "capacity to live actively and independently" instead of a "disease-free condition". Epidemiological

452 studies indicate six domains that could be used to define healthy aging: (1) general health, (2)

453 locomotor/physical capabilities, (3) cognitive functions, (4) sensory functions, (5) psychological

454 conditions, and (6) vitality/metabolism function.

455   We propose a conceptual framework of a life course approach on service coverage

456 monitoring as an input-process-output-outcome concept (Figure 3). Input would be the key points of

457 the life course approach based on recent policies/services/programs. Process monitors and evaluates

458   the policies/services/programs for improvement. Through this system, a healthy aging population, as

459   represented by the six domains, is expected.
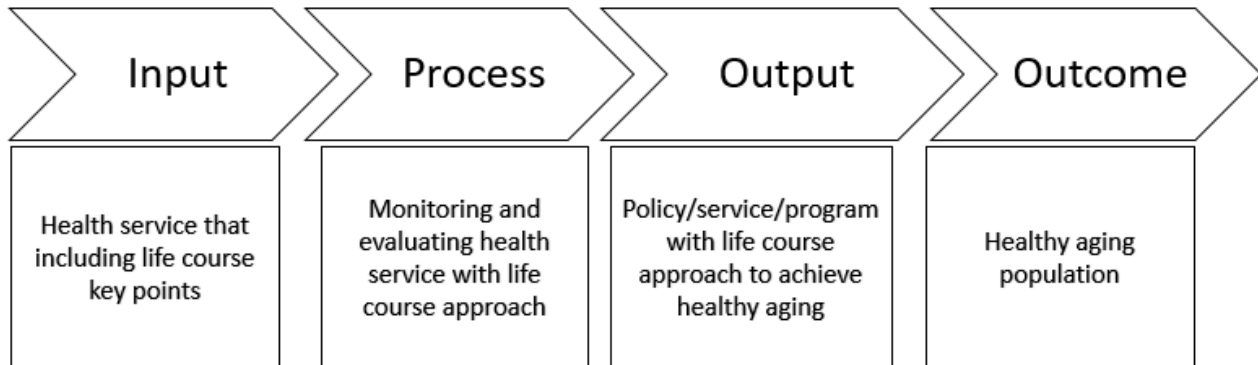
460

461   Figure 3. The conceptual framework of the life course approach on service coverage monitoring as an

462   input-process-output-outcome concept.

463   Recent work has not proposed specific policies/services/programs or introduced

464   indicators for a life course approach to improve service coverage and monitoring ~~due to limited~~

465   ~~information from literature review~~. Future work and effort are needed to translate recent conceptual

466   frameworks and findings of the literature review into action. Because any life course approach is

467   complex and multidimensional, a collaborative and multiorganizational effort is necessary.

468   One study identified maternal and child health (MCH) life course indicators [84]. That

469   study proposed assessing, monitoring, and evaluating the application of life course principles to public

470   health. It also proposed a conceptual framework and a set of 59 indicators that showed overlap with

471   existing public health measures. Thus, a life course approach does not mean starting from scratch.

472   Three other studies informed the importance of vaccination programs for adult and

473   older populations [46-48]. Vaccinations are renowned as one of the most effective public health

474   services in history [46]. Preventing disease through vaccinations also means protecting older people

475   through herd immunity. To achieve healthy aging, we should expand vaccinations beyond children

476 and to adult and older people. At present, there is low coverage of adult vaccination, which means a

477 higher risk and burden in vaccine-preventable diseases.

478   To implement a life-course approach in LMICs, we realized several challenges. First,

479 LMICs have limited data, especially on noncommunicable diseases [10, 83]. Second, integrated care

480 for older people is sparse [45]. Finally, financial constraints are still obstacles for LMICs to inclusively

481 provide health services beyond clinical and curative interventions [10].

482 **Strengths and limitations**

483 The present study provided an overview of the available research to identify the nature and knowledge

484 gaps about policies, services, interventions and related research (i.e. epidemiological articles) aimed

485 at improving the health and function of older people based on a life course approach or framework.

486 We further fit it into a conceptual framework to compare with UHC monitoring systems. This work

487 followed a systematic and robust process and also involved consulting experts from Thailand and

488 Indonesia on LMIC efforts and experiences.

489   The major limitation of the present study is that we limit our discussion to service

490 coverage monitoring, but financial protection should also be considered. We therefore encourage

491 future study to investigate life course approaches on financial protection. Our literature review also

492 has a few weaknesses. Alternative media, such as dissertations and books, were not included in the

493 literature search, although we did include some books from snowball sampling and experts'

494 recommendations. We decided to include mostly published articles, since policy/services/intervention

495 discussions were mainly available on this database. We also used limited string and word combinations,

496 thus, we may have missed some relevant papers. Nonetheless, this method was needed to maintain the

497 focus of our content. Also, most studies we retrieved were from high-income country settings, even

498 though our initial objective was to address LMICs. Our scoping review was also assessed individually,

499 instead of using two investigators to cross-check a paper. However, we conducted a group discussion

500 to evaluate each investigator's results and two coordinators cross-checked the inclusion and exclusion

501 criteria, missing data, and questionable content of the extracted data.

502 **Conclusion**

503 The present study suggested a life course approach may be useful to reforming health systems in

504 LMICs with aging populations in order to achieve UHC. We proposed a conceptual framework of a

505 life course approach to achieve healthy aging. This conceptual framework facilitated us to conduct a

506 literature review and interpret the results. During the literature review, we investigated previous studies

507 on life course approaches for health policies/services/programs and suggested possible areas for future

508 research in service coverage monitoring. We combined the conceptual framework and results of the

509 literature review to examine recent service coverage monitoring and suggest future efforts to improve

510 monitoring systems. Using key points of the life course and healthy aging as outcomes, this study

511 conceptualised service coverage monitoring using a life course approach.

512 For future study, we highly recommended to transform recent conceptual frameworks

513 and findings into applicable action. A future study that includes financial protection is also needed.

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