论著·公共卫生智库

中国高空腹血糖相关缺血性脑卒中疾病负担评估、趋势预测与重点人群防控策略:基于GBD 2021的公共卫生预警

周银娟[1,2],王 文[1,2],魏海萍[2] 兰州大学:[1]第二临床医学院;[2]第二医院神经内科,甘肃兰州

[摘要] **目的** 本研究基于2021年全球疾病负担研究(global burden of disease, GBD)数据,系统评估1990—2021年中国25岁以上人群归因于高空腹血糖(high fasting plasma glucose, HFPG)的缺血性脑卒中(ischemic stroke, IS)疾病负担,分析人群差异,并预测2022—2035年趋势。**方法** 数据来源于GBD 2021数据库,提取中国地区1990—2021年HFPG相关缺血性脑卒中的年龄标化死亡率(age-standardized mortality rate, ASMR)、年龄标化伤残调整生命年率(age-standardized disability-adjusted life years rate, ASDR)及人群亚组数据。采用Joinpoint回归分析时间趋势,贝叶斯年龄-时期-队列(bayesian age-period-cohort, BAPC)模型预测未来负担变化。**结果** 1990—2021年中国25岁以上人群HFPG相关缺血性脑卒中的ASMR和ASDR整体呈下降趋势,但2021年ASMR(19.76/10万)和ASDR(354.37/10万人年)仍显著高于全球水平(ASMR=14.69/10万;ASDR=266.36/10万人年)。男性负担高于女性,25~44岁群体负担呈上升趋势,80岁以上人群下降趋势不显著。预测显示,2022—2035年中国ASMR和ASDR将持续下降,降幅预计高于全球,但绝对水平仍高于全球。**结论** 中国≥25岁人群HFPG相关缺血性脑卒中疾病负担虽整体下降,但防控形势仍严峻。需针对男性、老年及年轻高危人群制定精准干预策略,加强糖尿病管理与健康促进,以遏制疾病负担上升。**对策** 建议强化高危人群血糖筛查与基层规范管理,针对男性、老年及年轻高危人群制定精准干预策略,完善卒中救治——康复连续服务和医保保障,建立监测评估与预警体系,以遏制HFPG相关IS负担。

[关键词] 缺血性脑卒中;风险因素;全球疾病负担;死亡率;伤残调整生命年

[中图法分类号] R-05;R195.4;R743.3 [文献标志码] A

Assessment of disease burden and trend prediction of ischemic stroke attributable to high fasting plasma glucose in China: prevention and control strategies for key populations—a public health early warning based on GBD 2021

ZHOU Yinjuan[1,2], WANG Wen[1,2], WEI Haiping[2] [1]Second Clinical Medical School, Lanzhou University, Lanzhou, Gansu; [2]Department of Neurology, Lanzhou University Second Hospital, Lanzhou, Gansu, China

[**Abstract**] Objective To systematically assess the disease burden of ischemic stroke (IS) attributable to high fasting plasma glucose (HFPG) among Chinese adults aged 25 years and older from 1990 to 2021 based on 2021 Global Burden of Disease (GBD) data, and to analyze population disparities and project trends for 2022 to 2035, providing evidence for prevention and control strategies. Methods Data were

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[通信作者] 魏海萍,E-mail:ery_weihpery@lzu.edu.cn

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extracted from the GBD 2021 database, including age-standardized mortality rate (ASMR), disability-adjusted life years per million (ASDR), and population subgroup data for HFPG-related IS in China from 1990 to 2021. Joinpoint regression model was used to analyze temporal trends, and Bayesian age-period-cohort (BAPC) model was employed to predict future burden changes. **Results** Overall, both the ASMR and ASDR for HFPG-related IS showed a declining trend from 1990 to 2021 among individuals aged 25 and older in China. However, in 2021, the ASMR (19.76 per 100 000) and ASDR (354.37 per 100 000 person-years) remained significantly higher than the global levels (ASMR=14.69 per 100 000; ASDR=266.36 per 100 000 person-years). The disease burden was higher in males than in females, with an increasing trend among those aged 25 to 44 years and a non-significant decline among those aged 80 years and older. Projections indicated that China's ASMR and ASDR will be in a continuous decline from 2022 to 2035, with a projected rate of decrease exceeding the global average, though absolute levels will still remain higher than the global average. **Conclusion** Although the overall burden of HFPG-related is among Chinese individuals aged ≥25 years has decreased, the prevention and control situation remains severe. **Countermeasures** It is recommended to enhance blood glucose screening for high-risk populations and standardized primary care management. Precise intervention strategies should be formulated for males, the elderly, and other young high-risk groups. Additionally, it is essential to improve the continuum of stroke treatment, rehabilitation services, and medical insurance coverage, while establishing a monitoring, evaluation, and early warning system to curb the burden of hyperglycemia-related ischemic stroke.

[**Key words**] ischemic stroke; risk factors; global burden of disease; mortality; disability-adjusted life years

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缺血性脑卒中(ischemic stroke, IS)作为高发病率与高致残率的脑血管疾病,近年来其发病率和疾病负担持续上升,已构成重大公共健康挑战[1]。2021年,IS在全球范围内导致的伤残调整生命年(disability-adjusted life years, DALYs)约为7 035.79万人年。尽管其年龄标准化率有所下降,但受人口增长与老龄化的双重影响,该疾病的绝对负担依然维持在较高水平[2]。中国因人口基数大、老龄化进程快,IS绝对负担已居全球前列。更有研究表明,全球25岁以上人群罹患脑卒中的终身风险为24.9%,而我国接近40%[3]。

HFPG与IS的发病风险息息相关[4]。全国性数据分析显示,2018年中国因HFPG导致的心血管疾病死亡人数约为49.9万,归因于HFPG的心血管疾病寿命损失高达每10万人1 076人年,且中-高社会人口学指数(socio-demographic index, SDI)地区尤为显著[5]。此外,长期高水平血糖暴露与卒中风险持续升高相关。在中国大规模社区队列中,空腹血糖≥7.0 mmol/L者卒中风险显著高于正常队列,女性和绝经后女性尤为明显[6]。GBD等权威数据库的分析和预测显示,若HFPG等代谢危险因素得不到有效控制,未来中国IS疾病负担可能存在上升风险[7]。然而,关于中国人群中HFPG导致的IS疾病负担的长期变化趋势及预测研究,依旧相对匮乏。因此本研究基于GBD 2021数据系统评估1990—2021年我国25岁以上人群归因于HFPG的IS疾病负担及不同年龄、性别组差异,并对2022—2035年由HFPG所致的IS负担演变趋势进行预测,为我国脑卒中防治行动提供定量依据,同时为制定HFPG相关IS的精准防控策略提供数据支撑。

1 资料与方法

1.1 数据来源和疾病定义

本研究使用GBD 2021数据库(https://vizhub.healthdata.org/gbd-results/),该数据库通过疾病监测、死因登记、队列研究、横断面调查等多种数据收集方式,记录了全球204个国家及地区、811个次国家级别的流行病学数据,覆盖371种疾病、伤害以及88种风险因素相关的健康结果评估。GBD 2021采用贝叶斯正则化截尾回归模型和时空高斯过程回归模型等方法对不同来源数据进行标准化处理,具有跨地区、跨时间段的可比性和可靠性[7]。

本研究从GBD 2021数据库中提取全球和中国地区25岁以上人群1990—2021年相关数据,IS对应国际疾病分类10版(international classification of diseases, 10th revision,ICD-10)编码I63.0-I63.9。HFPG指空腹血糖超过理论最低风险暴露区间(theoretical minimum risk exposure level,TMREL,即5.0~5.6 mmol/L)的上限[8-9]。结局指标包括ASMR、ASDR及对应的95%不确定区间(confidence interval, *CI*)。DALYs由早死损失生命年(years of life lost, YLLs)与伤残损失生命年(years lived with disability, YLDs)组成。年龄标准化率采用GBD 2021世界标准人口计算,该标准基于2010—2025年全球人口的年龄结构。为满足人群亚组分析需求,数据按照性别和15个年龄组进行分层提取,年龄组包括25~29岁、30~34岁……90~94岁以及≥95岁[9]。

1.2 趋势分析:Joinpoint回归模型

采用Joinpoint回归模型识别1990—2021年HFPG相关缺血性脑卒中ASMR和ASDR的时间趋势转折点,模型将研究期划分为若干线性区间,基于分段线性回归模型计算不同时间区间的年度变化百分比(annual percent change, APC)及整个研究期间的平均年度变化百分比(average annual percent change, AAPC),并给出95% *CI*[10-11]。模型参数设置基于32个年度数据,最大连接点数设为6,通过加权贝叶斯信息准则(weighted bayesian information criterion, WBIC)选择最优模型,并使用蒙特卡罗置换法检验转折点的统计学显著性。若APC或AAPC的95% *CI*下限>0,提示上升趋势;若上限<0,提示下降趋势;若置信区间包含0,则无统计学意义[10]。

1.3 预测分析:贝叶斯年龄-时期-队列模型

运用贝叶斯年龄-时期-队列(bayesian age-period-cohort,BAPC)模型对2022—2035年IS疾病负担趋势进行预测。该模型以1990—2021年间按年龄组和年份划分的数据为基础,综合考虑年龄、时期和队列效应,采用二阶随机游走先验分布,并借助综合嵌套拉普拉斯近似(integrated nested laplace approximation, INLA)方法开展贝叶斯推断。通过交叉验证对模型的准确性进行评估,确保平均绝对百分比误差(mean absolute percentage error, MAPE)低于15%,随后利用验证后的模型对未来疾病负担进行外推预测,同时计算出95%的不确定性区间[12]。

1.4 统计学方法

本研究使用Excel 2016软件对1990—2021年中国因空腹血糖升高导致的IS疾病负担数据进行整理,采用Joinpoint 5.4.0软件评估疾病负担变化趋势,运用R 4.5.1软件的BAPC包对2022—2035年中国因空腹血糖高导致的IS疾病负担进行预测分析,运用Origin 2024和Adobe Illustrator 2024软件进行数据可视化。$P<0.05$为差异具有统计学意义。

2 结果

2.1 1990—2021年中国HFPG致IS疾病负担特征

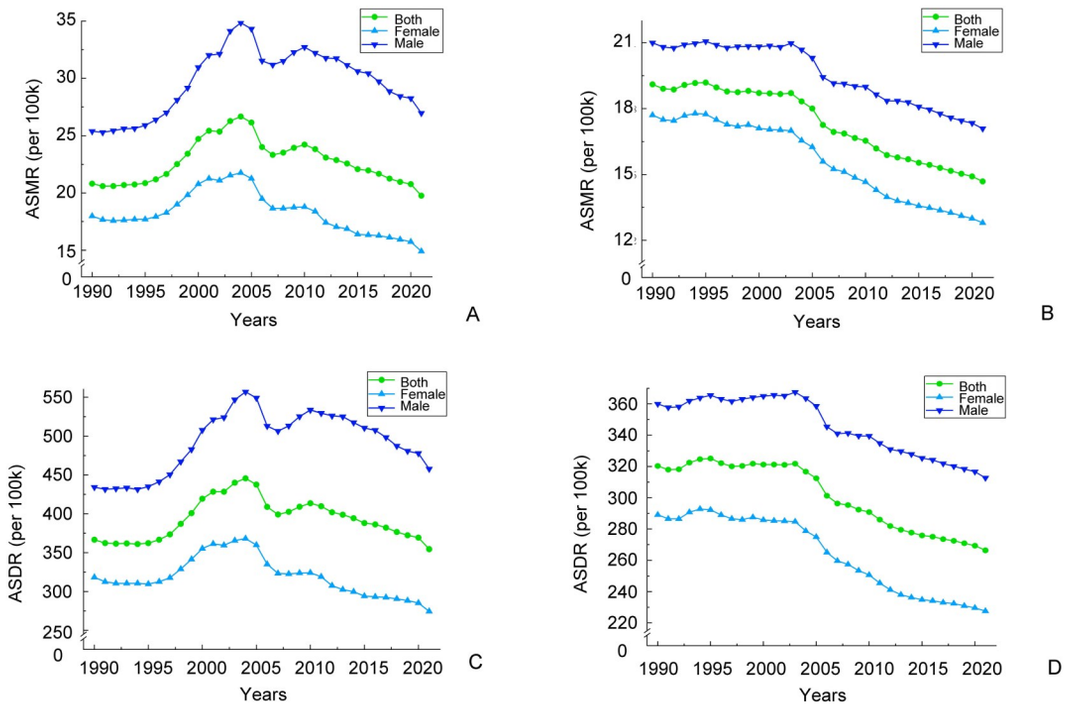
研究显示,1990—2021年全球和中国由HFPG导致的缺血性脑卒中ASMR和ASDR均呈下降趋势,特别是女性人群的下降幅度尤为显著;中国全人群的疾病负担变化呈现"先升后降"的波动模式,而男性人群的负担略有上升。2021年,中国的ASMR(19.76/10万)与ASDR(354.37/10万人年)均高于全球水平(ASMR=14.69/10万;ASDR=266.36/10万人年)。Joinpoint分析结果显示,在2010年之前中国ASMR和ASDR波动显著,2004—2006年间的ASMR和ASDR下降幅度最大(ASMR APC=-4.63%;ASDR APC=-3.86%),尽管自2010年以来两者进入持续下降阶段,但由于此前的波动上升及近期下降速度仍相对有限,中国整体的下降速度未能超越全球水平,见图1,表1、2。

表1 1990—2021年中国和全球HFPG所致IS疾病负担的AAPC

Table 1 AAPC of the disease burden of IS due to HFPG in China and globally from 1990 to 2021

Item	ASMR/100 000				ASDR/100 000			
	1990	2021	AAPC(95% *CI*)	*P*	1990	2021	AAPC(95% *CI*)	*P*
China								
Both	20.82	19.76	-0.07(-0.48~0.33)	0.727	366.54	354.37	-0.02(-0.34~0.30)	0.908
Male	25.37	26.95	0.30(-0.14~0.74)	0.176	434.09	457.65	0.21(-0.16~0.57)	0.269
Female	17.98	14.91	-0.49(-1.06~0.07)	0.087	318.26	274.37	-0.39(-0.80~0.02)	0.064
Global								
Both	19.11	14.69	-0.84(-0.98~-0.71)	<0.001[a]	320.33	266.36	-0.58(-0.71~-0.45)	<0.001[a]
Male	21.00	17.09	-0.63(-0.75~-0.51)	<0.001[a]	359.93	312.68	-0.43(-0.52~-0.35)	<0.001[a]
Female	17.70	12.80	-1.00(-1.23~-0.77)	<0.001[a]	289.04	227.54	-0.74(-0.87~-0.61)	<0.001[a]

a: $P<0.05$; AAPC: Average annual percent change; IS: Ischemic stroke; HFPG: High fasting plasma glucose; ASMR: Age-standardized mortality rate; ASDR: Age-standardized disability-adjusted life years rate; *CI*: Confidence interval



A: ASMR in China; B: Global ASMR; C: ASDR in China; D: Global ASDR. ASMR: Age-standardized mortality rate; ASDR: Age-standardized disability-adjusted life years rate; IS: Ischemic stroke; HFPG: High fasting plasma glucose

图1 1990—2021年中国和全球HFPG所致IS的ASMR和ASDR变化趋势

Figure 1 Trends of ASMR and ASDR in IS caused by HFPG in China and globally from 1990 to 2021

表2 1990—2021年中国不同性别群体HFPG所致IS疾病负担的Joinpoint结果

Table 2 Joinpoint results of the disease burden of IS due to HFPG in different gender groups in China from 1990 to 2021

Item	ASMR/100 000			ASDR/100 000		
	Period	APC(95% *CI*)	*P*	Period	APC(95% *CI*)	*P*
Both	1990—1996	0.22(−0.25~0.70)	0.338	1990—1996	−0.07(−0.45~0.31)	0.688
	1996—2000	4.13(2.75~5.53)	<0.001[a]	1996—2000	3.63(2.54~4.73)	<0.001[a]
	2000—2004	2.21(0.92~3.51)	0.002[a]	2000—2004	1.76(0.74~2.79)	0.002[a]
	2004—2007	−4.63(−7.08~−2.11)	0.001[a]	2004—2007	−3.86(−5.82~−1.86)	0.001[a]
	2007—2010	1.21(−1.37~3.86)	0.335	2007—2010	1.35(−0.70~3.44)	0.181
	2010—2021	−1.62(−1.80~−1.43)	<0.001[a]	2010—2021	−1.23(−1.37~−1.09)	<0.001[a]
Male	1990—1996	0.66(0.06~1.26)	0.032[a]	1990—1996	−0.14(−0.78~0.51)	0.650
	1996—2004	3.79(3.35~4.24)	<0.001[a]	1996—2004	3.00(2.71~3.29)	<0.001[a]
	2004—2007	−4.34(−7.29~−1.29)	0.008[a]	2004—2007	−3.61(−5.98~−1.18)	0.007[a]
	2007—2010	2.27(−0.91~5.56)	0.153	2007—2010	2.08(−0.46~4.69)	0.102
	2010—2021	−1.61(−1.84~−1.38)	<0.001[a]	2010—2016	−0.86(−1.43~−0.28)	0.006[a]
				2016—2021	−1.87(−2.51~−1.23)	<0.001[a]
Female	1990—1996	−0.09(−0.91~0.74)	0.825	1990—1996	−0.33(−0.93~0.27)	0.260
	1996—2000	4.07(1.75~6.44)	0.002[a]	1996—2000	3.53(1.84~5.24)	<0.001[a]
	2000—2004	1.31(−0.80~3.47)	0.211	2000—2004	1.01(−0.53~2.58)	0.188
	2004—2007	−4.46(−8.52~−0.21)	0.041[a]	2004—2007	−3.89(−6.90~−0.79)	0.017[a]
	2007—2021	−1.58(−1.80~−1.36)	<0.001[a]	2007—2021	−1.15(−1.30~−0.99)	<0.001[a]

a: *P*<0.05; IS: Ischemic stroke; HFPG: High fasting plasma glucose; ASMR: Age-standardized mortality rate; ASDR: Age-standardized disability-adjusted life years rate; APC: Annual percent change; *CI*: Confidence interval

2.2 不同年龄段归因于HFPG的IS疾病负担趋势分析

2021年不同年龄组趋势分析显示,中国各年龄段归因于HFPG的IS疾病负担均超出了全球水平。其中,在25~89岁年龄组其疾病负担随年龄递增,在90+年龄组轻微下降。同比1990年,2021年中国归因HFPG的IS死亡率和DALYs率在80岁以下人群有所下降,而在80岁以上人群略微上升,见图2。死亡率和DALYs率的AAPC呈波动性变化,在25~44岁年龄段呈显著上升趋势,45~79岁年龄段呈下降趋势,80+年龄组呈轻度上升,但并不显著。全球水平的死亡率和DALYs率先上升后下降,75~79岁年龄组下降最快,其死亡率和DALYs率分别为-0.99%和-0.80%。在45~69岁,中国归因HFPG的疾病负担的下降幅度大于全球水平,而在70+年龄组,中国疾病负担的下降幅度普遍小于全球,见表3。

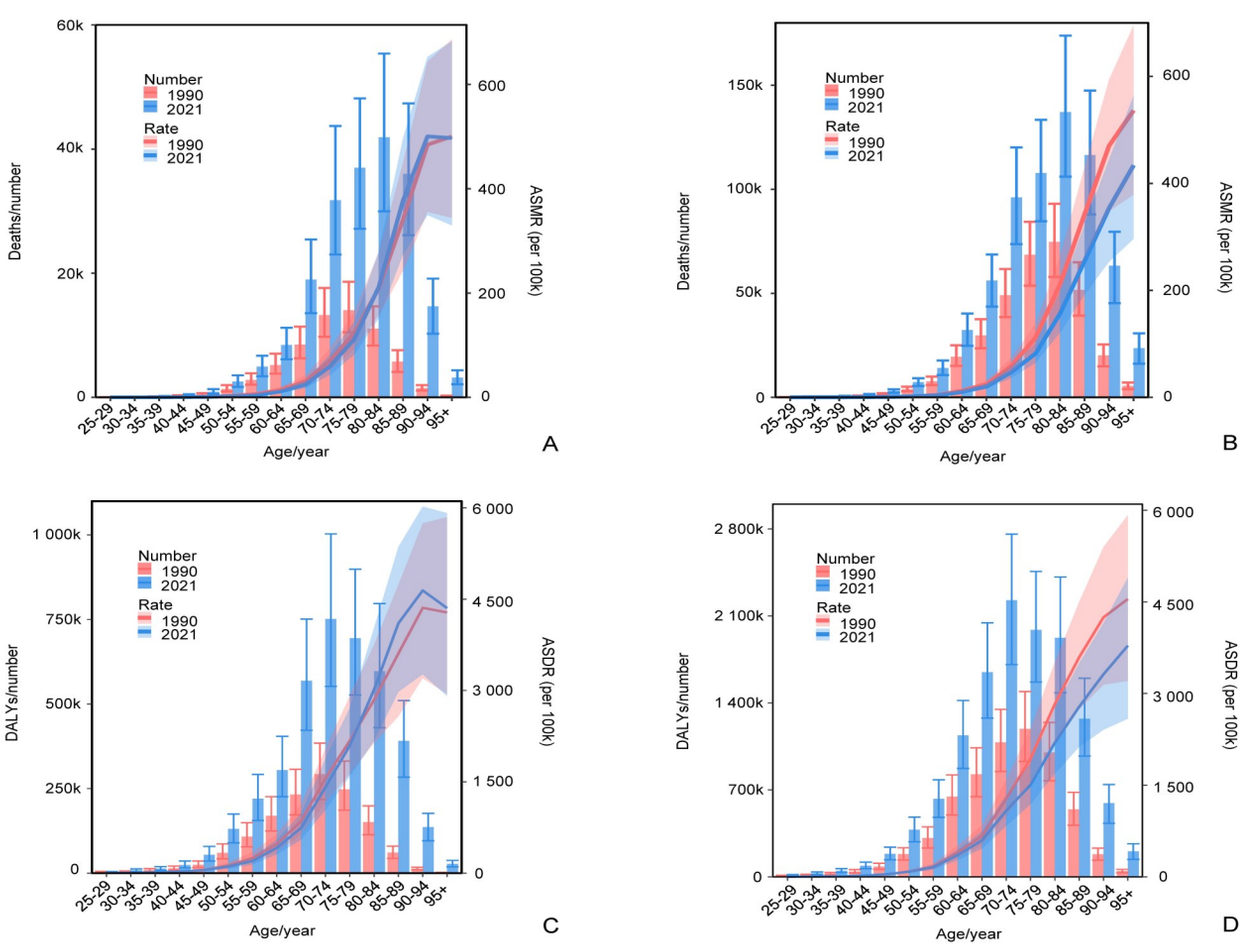
2.3 2022—2035年中国归因于HFPG的IS疾病负担预测

BAPC模型预测结果表明,2022—2035年,中国及全球范围内因HFPG所致的IS负担均将持续降低,其中中国的下降趋势更为显著。截至2035年,中国ASMR和ASDR将分别下降至12.71/10万和268.23/10万人年,全球ASMR和ASDR将分别下降至12.65/10万和251.76/10万人年。见图3、表4。

3 讨论

3.1 1990—2021年中国HFPG相关IS疾病负担变化趋势分析

2021年,在GBD全因等级的第3级中,中风是继缺血性心脏病和2019年冠状病毒病(corona virus



A, B: Mortality numbers and rates in Chinese (A) and globally (B); C, D: Disability-adjusted life years and rates in Chinese (C) and globally (D). IS: Ischemic stroke; HFPG: High fasting plasma glucose

图2 1990—2021年中国和全球HFPG所致IS各年龄组的疾病负担变化情况

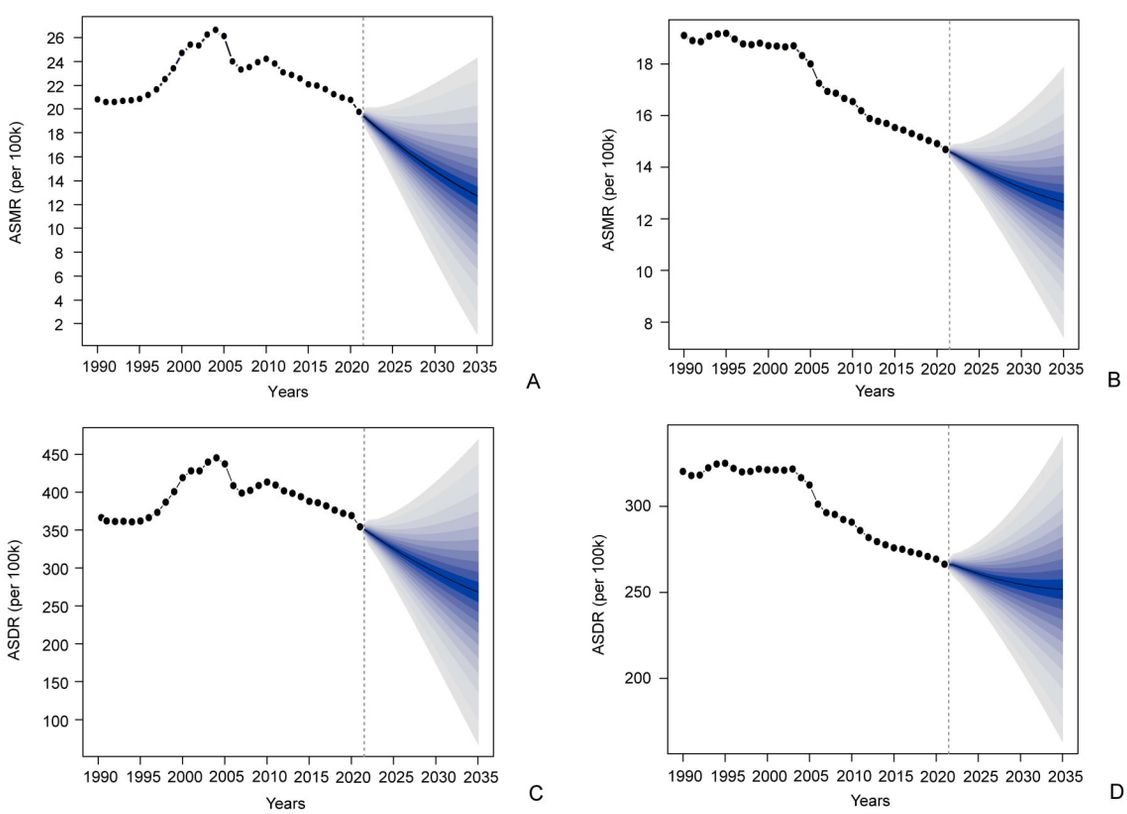
Figure 2 Changes in the disease burden of IS attributable to HFPG in different age groups in China and globally from 1990 to 2021

表3 1990—2021年中国和全球不同年龄段HFPG所致IS疾病负担的AAPC

Table 3 AAPC of disease burden of IS due to HFPG by age groups in China and globally from 1990 to 2021

Age group	Mortality in China		DALYs rate in China		Global mortality		Global DALYs rate	
	AAPC(95% *CI*)	*P*	AAPC(95% *CI*)	*P*	AAPC(95% *CI*)	*P*	AAPC(95% *CI*)	*P*
25~29	0.72(0.33~1.11)	<0.001[a]	0.78(0.51~1.04)	<0.001[a]	0.08(−0.17~0.32)	0.537	0.34(0.15~0.52)	<0.001[a]
30~34	0.91(0.24~1.58)	0.008[a]	1.03(0.61~1.46)	<0.001[a]	0.42(−0.05~0.90)	0.082	0.72(0.46~0.99)	<0.001[a]
35~39	0.59(0.21~0.98)	0.003[a]	0.90(0.65~1.15)	<0.001[a]	0.34(0.11~0.56)	0.003[a]	0.62(0.49~0.75)	<0.001[a]
40~44	0.37(−0.13~0.87)	0.151	0.75(0.46~1.03)	<0.001[a]	0.32(0.12~0.53)	0.002[a]	0.60(0.47~0.74)	<0.001[a]
45~49	−0.40(−0.95~0.15)	0.155	0.06(−0.37~0.49)	0.793	0.00(−0.43~0.44)	0.993	0.31(−0.00~0.63)	0.051
50~54	−0.88(−1.22~−0.53)	<0.001[a]	−0.46(−0.82~−0.10)	0.013[a]	−0.29(−0.55~−0.03)	0.027[a]	0.00(−0.20~0.21)	0.967
55~59	−1.08(−1.39~−0.77)	<0.001[a]	−0.65(−0.88~−0.41)	<0.001[a]	−0.43(−0.64~−0.22)	<0.001[a]	−0.15(−0.33~0.03)	0.093
60~64	−0.68(−1.15~−0.21)	0.005[a]	−0.35(−0.73~0.03)	0.067	−0.56(−0.80~−0.33)	<0.001[a]	−0.38(−0.58~−0.17)	<0.001[a]
65~69	−0.68(−0.94~−0.41)	<0.001[a]	−0.39(−0.65~−0.13)	0.003[a]	−0.50(−0.70~−0.30)	<0.001[a]	−0.32(−0.49~−0.15)	<0.001[a]
70~74	−0.45(−0.73~−0.18)	0.001[a]	−0.23(−0.47~0.01)	0.065	−0.65(−0.90~−0.41)	<0.001[a]	−0.52(−0.77~−0.28)	<0.001[a]
75~79	−0.22(−0.53~0.09)	0.163	−0.03(−0.31~0.26)	0.854	−0.99(−1.12~−0.87)	<0.001[a]	−0.80(−0.90~−0.71)	<0.001[a]
80~84	0.12(−0.45~0.69)	0.691	0.27(−0.20~0.75)	0.261	−0.91(−1.01~−0.80)	<0.001[a]	−0.76(−0.86~−0.67)	<0.001[a]
85~89	0.41(−0.22~1.04)	0.202	0.50(−0.09~1.11)	0.099	−0.89(−1.08~−0.70)	<0.001[a]	−0.80(−1.03~−0.57)	<0.001[a]
90~94	0.21(−0.40~0.82)	0.502	0.30(−0.28~0.89)	0.310	−0.91(−1.04~−0.77)	<0.001[a]	−0.79(−0.91~−0.66)	<0.001[a]
≥95	0.20(−0.26~0.66)	0.404	0.25(−0.19~0.70)	0.268	−0.68(−0.85~−0.51)	<0.001[a]	−0.59(−0.75~−0.42)	<0.001[a]

a: *P*<0.05; AAPC: Average annual percent change; IS: Ischemic stroke; HFPG: High fasting plasma glucose; DALYs: Disability-adjusted life years; *CI*: Confidence interval



A: ASMR in China; B: Global ASMR; C: ASDR in China; D: Global ASDR. The areas of color from light to dark in the figure represent increasing confidence intervals (*CI*) in a gradient of 5%, ranging from 5% to 95%. ASMR: Age-standardized mortality rate; ASDR: Age-standardized disability-adjusted life years rate; IS: Ischemic stroke; HFPG: High fasting plasma glucose

图3 2022—2035年中国和全球HFPG所致IS的疾病负担预测

Figure 3 Projected burden of disease for IS due to HFPG in China and globally from 2022 to 2035

表4 2022—2035年中国和全球HFPG所致IS的ASMR和ASDR预测

Table 4 ASMR and ASDR predictions for IS due to HFPG in China and globally from 2022 to 2035

Year	ASMR in China(95% *CI*) (per 100 000)	ASDR in China(95% *CI*) (per 100 000)	Global ASMR(95% *CI*) (per 100 000)	Global ASDR(95% *CI*) (per 100 000)
2022	19.12(18.13~20.11)	347.13(331.22~363.04)	14.52(14.16~14.89)	265.95(259.8~272.1)
2023	18.51(16.95~20.08)	339.58(315.03~364.12)	14.33(13.76~14.91)	264.16(254.81~273.51)
2024	17.93(15.65~20.2)	332.29(296.89~367.69)	14.16(13.32~14.99)	262.49(249.02~275.96)
2025	17.36(14.31~20.41)	325.26(277.61~372.9)	13.98(12.85~15.11)	260.92(242.66~279.17)
2026	16.81(12.94~20.67)	318.44(257.56~379.31)	13.81(12.35~15.26)	259.39(235.82~282.95)
2027	16.27(11.56~20.98)	311.87(237.01~386.73)	13.64(11.83~15.45)	258.01(228.66~287.36)
2028	15.76(10.19~21.33)	305.57(216.13~395.01)	13.49(11.31~15.66)	256.82(221.27~292.37)
2029	15.27(8.83~21.71)	299.54(195.05~404.02)	13.34(10.77~15.91)	255.76(213.63~297.89)
2030	14.8(7.48~22.11)	293.75(173.85~413.66)	13.21(10.23~16.18)	254.81(205.75~303.86)
2031	14.34(6.16~22.52)	288.18(152.55~423.81)	13.07(9.68~16.47)	253.91(197.61~310.21)
2032	13.9(4.87~22.94)	282.84(131.22~434.46)	12.95(9.13~16.78)	253.16(189.27~317.06)
2033	13.49(3.6~23.37)	277.74(109.91~445.57)	12.84(8.57~17.12)	252.59(180.76~324.41)
2034	13.09(2.37~23.81)	272.87(88.63~457.11)	12.74(8.00~17.48)	252.13(172.07~332.2)
2035	12.71(1.16~24.26)	268.23(67.42~469.04)	12.65(7.43~17.86)	251.76(163.15~340.36)
AAPC	−3.09[a](−3.10~−3.09)	−1.97[a](−1.98~−1.95)	−1.06[a](−1.08~−1.05)	−0.42[a](−0.43~−0.41)
P	<0.001[a]	<0.001[a]	<0.001[a]	<0.001[a]

a: $P<0.05$; ASMR: Age-standardized mortality rate; ASDR: Age-standardized disability-adjusted life years rate; IS: Ischemic stroke; HFPG: High fasting plasma glucose; *CI*: Confidence interval; AAPC: Average annual percent change

disease 2019, COVID-19)之后第三大常见死因,也是第四大致DALYs的原因[7]。中国作为人口基数庞大且老龄化进程加快的国家,其相应疾病负担更需重点关注。本研究显示,过去30年间,全球和中国HFPG相关IS的ASMR和ASDR整体呈下降趋势,这与以往的研究结果一致[13],表明国家目前加大对糖尿病医疗资源的投入和健康教育的宣传策略有效[14-15]。2004—2006年我国整体卒中负担大幅下降,这一趋势与2003年起我国推广第一部糖尿病防治指南,2004年起糖尿病的诊断标准更加严格,以及同年设立“世界卒中日”等一系列举措相关[16-17]。2007年我国开始实施卒中登记,在2013年完成了针对50万人的全国代表性卒中流行病学调查,并在2015年开展第三期卒中调查项目,评估医疗服务情况[18],这与2010年后负担下降的趋势相吻合。但是与全球IS的下降趋势相比,我国疾病负担依旧显著。

3.2 1990—2021年中国不同性别和年龄群体归因HFPG的IS疾病负担分析

性别分析显示,男性归因HFPG的IS疾病负担比女性更高。在生理差异方面,雄激素促进脂肪分布和代谢,容易形成腹部肥胖和胰岛素抵抗,导致血糖升高[19]。生活方式方面,男性吸烟和饮酒的比例高于女性,这些行为会损害血管内皮细胞,导致血糖升高,增加卒中风险;男性更倾向于高热量、高脂肪和高盐的饮食,缺乏运动,这些因素与HFPG发挥协同作用,共同增加卒中风险[20]。社会文化方面,传统男性角色观念导致他们健康意识较低、就医行为较差,对慢性病的知晓率、治疗率和控制率普遍低于女性[21]。因此未来的公共卫生策略必须超越单一风险因素的干预,转向针对男性的综合性预防策略。公共卫生宣传应更具针对性,使用男性更容易接受的语言和渠道,普及脑卒中及其风险因素的知识。

不同年龄段分析显示,我国归因HFPG的IS疾病负担随着年龄的增加而逐渐上升。年龄本身是缺血性卒中不可逆转的危险因素,其影响在性别和糖尿病共存时呈现差异性[22]。糖尿病一方面可提升心血管事件概率,另一方面与缺血性卒中均通过上调炎症信号、增强氧化应激等病理机制发挥协同作用[23]。长期患有糖尿病可使脑血管可发生持续性结构损害与功能减退。此外,25~44岁群体的卒中负担有上升趋势,这可能与现代生活方式的改变,如久坐不动、高热量饮食、工作压力大等,导致代谢性危险因素在年轻一代中提前出现有关[24]。鉴于此,青年应加强推广健康生活方式并对高危者早筛,老年由多学科团队制定个

体化血糖目标,高龄人群侧重防跌倒、认知维护及家庭-社区连续照护,共同降低HFPG相关IS负担。

3.3 2022—2035年中国HFPG相关IS疾病负担预测分析

通过BAPC模型预测发现,2022—2031年中国由HFPG导致的脑卒中疾病负担呈下降趋势,这与我国近年来针对慢病采取的一系列措施和政策密不可分。在2007—2018年间,特别是随着高血压、糖尿病等危险因素管理以及卒中二级预防措施的加强,中国IS患者的复发率呈现出持续且显著的下降趋势,12个月内的复发率累计下降了3.0个百分点[25]。截至2024年6月,全国已建成三级医院卒中中心624家、二级医院卒中中心1387家,脑卒中患者的中位入院-用药时间(door-to-needle time, DNT)缩短至40分钟左右[26, 27]。2020年起,胰高血糖素样肽-1受体激动剂(glucagon-like peptide-1 receptor agonist, GLP-1RA)、钠-葡萄糖协同转运蛋白-2抑制剂(sodium-glucose cotransporter-2 inhibitor, SGLT-2i)等药物被纳入国家医保目录,部分地区报销比例≥70%,显著降低了合并动脉粥样硬化性心血管疾病(atherosclerotic cardiovascular disease, ASCVD)或其他高危因素的2型糖尿病患者的主要不良心血管事件(major adverse cardiovascular events, MACE)风险[28-29]。然而,研究表明2022—2035年间,IS疾病DALYs仍将持续上升[30]。因此,未来应继续扩大高危人群筛查覆盖面,提升县域溶栓率并压缩DNT,建成更多社区康复站提高二级预防规范执行率。

3.4 卫生政策建议

应构建“筛查—管理—转诊—救治—康复”全程闭环。将≥25岁高危人群(尤其是男性与中青年)纳入常规血糖与卒中风险筛查,依托基层开展糖尿病分层管理、处方指导和生活方式干预;完善分级诊疗与双向转诊,推进卒中中心网络下沉和院前急救联动,提升县域溶栓能力并压缩DNT;以社区康复站或家庭医生团队落实随访和二级预防。针对高龄与农村地区,加大医疗资源倾斜,强化“首诊在基层、转诊有通道、随访可到家”的连续照护,发展上门随访与长期照护支持。优化医保支付与药品准入,扩大GLP-1RA、SGLT-2i等具有心血管获益药物及必要康复服务保障,向预防和长期管理倾斜。建立HFPG相关卒中监测评估与预警机制,定期发布分地区负担报告,将血糖控制率、溶栓率、DNT、复发率等纳入慢病监测与绩效考核,实现政策动态优化。

本研究结果仍具有一定局限性。其一,输入数据多为模型外推而非实测记录,系统误差与参数假设可能被逐级放大;其二,关键暴露-结局链的证据缺口尚未补齐,潜在混杂或效应修饰因素仍可能扭曲归因风险;其三,分析层面止步于国家级别,省份和城乡差异未被充分考虑,局部卫生不平等被隐性抹平;其四,BAPC模型将干预场景与环境异质性简化为恒定参数,未来趋势可能因政策突变或生态剧变而偏离轨道。

综上,本研究显示,1990—2021年中国25岁以上人群归因HFPG的IS疾病负担整体下降,但仍高于全球且降幅较慢;男性负担高于女性,与生理、生活方式和社会文化差异相关。卒中负担随年龄增长而上升,25~44岁群体卒中负担增幅明显。BAPC模型预测2022—2031年我国IS疾病负担将持续下降,降幅超过全球。

利益冲突 本文所有作者声明不存在利益冲突

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