

 肿瘤登记  R 语言

# 基于肿瘤登记数据估计终生患癌风险

使用 R 语言

 陈琼 (河南省肿瘤医院)  chenq08@126.com

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# 1 终生患癌风险概念

## 1.1 疾病风险

某一结局事件（疾病）在一个特定时间范围内的发生的概率或可能性<sup>1</sup>。

### 为什么评估疾病风险？

- 公共卫生行动决策需要
- 合理分配公共卫生资源(时间和资金)

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<sup>1</sup>风险、机会、概率或可能性

## 1.2 风险和关联

流行病学中的关联是指暴露与结局之间的相关性。

### 关联的测量指标

- 相对风险(Relative risk)
- 比值比(Odds ratio)
- 归因风险(Attributable risk)
- 人群归因风险(Population attributable risk)
- 人群归因风险百分比(Population attributable risk percent)

## 1.3 估计风险的数据来源

- 队列研究
- 病例对照研究
- 流行病学调查
- 从已经发表或发布的死亡率
- 现有的疾病登记系统

## 1.4 绝对风险 VS 相对风险

**相对风险**(Relative risk, RR)，暴露组和对照组之间发生结局事件概率的比值，表示危险因素与结局事件的关联强度。

相对风险值通常以实际值展示，如 1.25 或 0.85。

- $RR > 1$ ，表示暴露组风险高于对照组
- $RR < 1$ ，表示暴露组风险低于对照组

与非吸烟人群相比，吸烟人群的肺癌相对风险为 1.25，表示吸烟人群的肺癌发生风险是非吸烟人群的 1.25 倍，或比非吸烟人群高 25%。

## 1.5 绝对风险 VS 相对风险

**绝对风险**(Absolute risk)，在特定的时期内特定人群发展为癌症的概率或可能性大小。

**终生患癌风险**是绝对风险的一种类型：

- 2020 年，全球人群从出生到死亡的生命周期内被诊断为癌症的概率为 25.10%，男性为 26.27%，女性为 23.98%<sup>2</sup>。
- 每四个人中有一人（1 in 4）会在整个生命周期内被诊断为癌。

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<sup>2</sup>Zheng RS, Wang SM, Zhang SW, et al. Global, regional, and national lifetime probabilities of developing cancer in 2020. [J] Sci Bull(Beijing). 2023;68(21):2620-2628.

# 1.6 终生患癌风险

终生患癌风险或终生癌症死亡风险特定人群在他们整个生命周期内被诊断为癌症或因癌症死亡的概率或可能性。

表 1 美国男性和女性特定癌种终生患癌风险

部位	男性		女性	
	%	1 in	%	1 in
全部	41.6	2	39.6	3
前列腺	12.9	8		
肺癌	6.3	16	5.9	17
结直肠癌	4.3	23	3.9	25
膀胱癌(包括原位癌)	3.6	28	1.1	89
皮肤黑色素瘤*	3.6	28	2.5	41
乳腺癌	0.1	726	13.0	8
非霍奇金淋巴瘤	2.4	42	1.9	52
肾和肾盂	2.3	43	1.4	73
淋巴瘤	1.9	53	1.3	75
胰腺癌	1.7	58	1.7	60
肝癌	1.5	65	0.7	143



表 2 全球居民终生癌症罹患风险<sup>3</sup>

Population	All	Esophagus	Stomach	Colorectum	Liver	Lung	Breast <sup>b</sup>	Prostate
World	25.10 (25.08–25.11)	0.93 (0.93–0.93)	1.77 (1.76–1.77)	3.16 (3.15–3.17)	1.36 (1.35–1.36)	3.61 (3.60–3.62)	5.90 (5.89–5.91)	4.65 (4.63–4.66)
Very high HDI	38.48 (38.44–38.52)	0.65 (0.64–0.65)	2.23 (2.22–2.24)	5.53 (5.52–5.55)	1.28 (1.28–1.29)	5.69 (5.67–5.70)	10.31 (10.28–10.33)	9.89 (9.86–9.92)
High HDI	25.38 (25.35–25.41)	1.46 (1.45–1.46)	2.36 (2.35–2.37)	3.28 (3.27–3.29)	2.10 (2.09–2.10)	4.30 (4.29–4.31)	5.09 (5.07–5.10)	3.34 (3.32–3.36)
Medium HDI	11.36 (11.33–11.39)	0.66 (0.66–0.67)	0.62 (0.61–0.63)	0.65 (0.65–0.66)	0.41 (0.41–0.42)	0.81 (0.80–0.82)	2.99 (2.97–3.01)	1.11 (1.09–1.13)
Low HDI	10.34 (10.27–10.40)	0.37 (0.36–0.38)	0.53 (0.51–0.54)	0.80 (0.78–0.81)	0.65 (0.63–0.66)	0.59 (0.57–0.61)	3.10 (3.06–3.13)	2.55 (2.49–2.61)
Eastern Africa	12.29 (12.19–12.39)	0.78 (0.76–0.81)	0.49 (0.47–0.51)	0.83 (0.80–0.86)	0.52 (0.50–0.54)	0.39 (0.37–0.41)	3.12 (3.07–3.17)	3.08 (2.98–3.18)
Middle Africa	9.52 (9.37–9.67)	0.24 (0.21–0.26)	0.41 (0.37–0.44)	0.66 (0.62–0.70)	0.54 (0.50–0.57)	0.24 (0.21–0.27)	2.67 (2.60–2.74)	3.88 (3.69–4.08)
Northern Africa	17.42 (17.31–17.53)	0.21 (0.20–0.22)	0.63 (0.61–0.65)	1.31 (1.27–1.34)	1.98 (1.95–2.02)	1.57 (1.53–1.60)	5.55 (5.49–5.62)	2.79 (2.70–2.88)
Southern Africa	16.64 (16.40–16.88)	0.68 (0.63–0.74)	0.33 (0.30–0.37)	1.34 (1.27–1.41)	0.44 (0.40–0.48)	1.68 (1.60–1.76)	5.13 (4.98–5.28)	5.23 (4.95–5.51)
Western Africa	8.59 (8.49–8.69)	0.11 (0.09–0.12)	0.34 (0.32–0.37)	0.55 (0.53–0.58)	0.68 (0.65–0.71)	0.19 (0.17–0.21)	3.31 (3.25–3.38)	2.71 (2.60–2.82)
Eastern Asia	32.35 (32.31–32.39)	2.15 (2.14–2.16)	4.16 (4.14–4.17)	4.72 (4.71–4.74)	2.76 (2.75–2.77)	6.32 (6.30–6.33)	5.28 (5.26–5.30)	3.33 (3.31–3.35)
South-Central Asia	11.35 (11.32–11.38)	0.70 (0.69–0.71)	0.70 (0.69–0.71)	0.67 (0.67–0.68)	0.36 (0.36–0.37)	0.82 (0.82–0.83)	2.89 (2.88–2.91)	0.92 (0.90–0.93)
South-Eastern Asia	18.73 (18.67–18.79)	0.27 (0.27–0.28)	0.81 (0.80–0.82)	2.18 (2.16–2.21)	1.92 (1.90–1.94)	2.59 (2.57–2.62)	4.93 (4.90–4.97)	2.04 (2.00–2.08)
Western Asia	24.19 (24.07–24.31)	0.30 (0.28–0.31)	1.44 (1.41–1.47)	2.67 (2.63–2.71)	0.83 (0.81–0.86)	4.11 (4.06–4.16)	5.77 (5.71–5.84)	4.84 (4.74–4.93)
Eastern Europe	27.86 (27.79–27.93)	0.36 (0.36–0.37)	1.61 (1.60–1.63)	4.23 (4.20–4.26)	0.62 (0.61–0.63)	3.61 (3.59–3.64)	7.13 (7.09–7.17)	5.64 (5.57–5.70)
Northern Europe	44.63 (44.48–44.77)	1.14 (1.11–1.16)	1.03 (1.01–1.05)	6.99 (6.94–7.05)	1.05 (1.03–1.07)	6.53 (6.47–6.58)	12.45 (12.35–12.54)	14.84 (14.72–14.97)
Southern Europe	40.61 (40.51–40.72)	0.33 (0.32–0.34)	1.74 (1.71–1.76)	6.68 (6.64–6.72)	1.35 (1.33–1.37)	5.56 (5.52–5.59)	11.36 (11.29–11.43)	10.02 (9.95–10.10)
Western Europe	44.08 (43.98–44.18)	0.77 (0.76–0.78)	1.26 (1.24–1.28)	6.16 (6.13–6.20)	1.14 (1.13–1.16)	6.10 (6.07–6.14)	12.85 (12.79–12.92)	13.57 (13.49–13.65)
Caribbean	25.96 (25.72–26.20)	0.45 (0.42–0.48)	1.18 (1.12–1.23)	3.23 (3.15–3.32)	0.95 (0.90–1.00)	3.14 (3.05–3.22)	6.56 (6.42–6.71)	10.97 (10.73–11.21)
Central America	18.53 (18.42–18.65)	0.18 (0.16–0.19)	1.26 (1.23–1.29)	1.67 (1.64–1.71)	1.16 (1.13–1.19)	0.99 (0.96–1.02)	4.93 (4.86–4.99)	7.03 (6.91–7.15)
South America	27.93 (27.85–28.01)	0.50 (0.48–0.51)	1.66 (1.64–1.68)	3.36 (3.33–3.39)	0.83 (0.82–0.85)	2.55 (2.53–2.58)	7.64 (7.60–7.69)	9.76 (9.68–9.84)
Northern America	39.78 (39.70–39.86)	0.52 (0.51–0.53)	0.77 (0.76–0.78)	4.48 (4.45–4.50)	1.11 (1.10–1.12)	6.52 (6.49–6.55)	12.43 (12.38–12.49)	10.32 (10.26–10.37)
Australia/New Zealand	47.68 (47.38–47.98)	0.75 (0.71–0.79)	1.03 (0.98–1.07)	7.38 (7.27–7.50)	1.19 (1.15–1.24)	5.96 (5.86–6.07)	13.88 (13.67–14.08)	13.60 (13.37–13.83)
Melanesia	17.20 (16.51–17.90)	0.39 (0.27–0.51)	0.85 (0.67–1.04)	1.20 (0.99–1.42)	1.09 (0.93–1.26)	1.41 (1.19–1.62)	4.78 (4.38–5.17)	3.59 (3.05–4.13)
Micronesia/Polynesia	32.48 (29.98–34.97)	0.35 (0.12–0.58)	1.46 (0.92–2.01)	2.74 (2.01–3.46)	1.55 (1.04–2.07)	6.45 (5.36–7.55)	8.73 (7.19–10.26)	10.00 (7.56–12.43)

<sup>a</sup> All sites exclude non-melanoma skin cancer.  
<sup>b</sup> Only for women.

<sup>3</sup>Zheng RS, Wang SM, Zhang SW, et al. Global, regional, and national lifetime probabilities of developing cancer in 2020. [J] Sci Bull(Beijing). 2023;68(21):2620-2628.

表 3    河南省居民终生癌症罹患风险和死亡风险<sup>4</sup>

Variable	Men, % (95 % CI)	Women, % (95 % CI)	Both genders, % (95 % CI)
Developing			
<b>All</b>	31.22 (30.59–31.85)	29.02 (28.12–29.91)	30.19 (29.63–30.76)
<b>Urban areas</b>	33.00 (31.68–34.32)	30.74 (29.08–32.40)	32.01 (30.87–33.15)
<b>Rural areas</b>	30.50 (29.79–31.22)	28.30 (27.25–29.35)	29.46 (28.82–30.11)
Dying			
<b>All</b>	26.73 (26.29–27.16)	20.08 (19.51–20.64)	23.62 (23.28–23.95)
<b>Urban areas</b>	27.64 (26.77–28.51)	20.92 (19.77–22.08)	24.53 (23.86–25.20)
<b>Rural areas</b>	26.37 (25.86–26.87)	19.78 (19.14–20.43)	23.29 (22.90–23.67)

<sup>4</sup>Chen Q, Liu SZ, Liu Y, et al. Journal of National Cancer Center[J]. 2025,5(2):140-148

## 1.7 终生患癌风险的度量指标

肿瘤登记是癌症负担数据的重要来源，基于登记处，通过定量评估患癌风险，可以为癌症负担描述提供一些新的视角。

1. 累积率/累积风险
2. 当前概率法- Current Probability (IARC scientific publication)
3. Devcan (SEER)
4. AMP method (Adjusted for Multiple Primary cancer)

## 1.8 累积率

$$\text{累积率} = \sum_{i=1}^A w_i p_i$$

- A 年龄组上限.
  - $w_i$  第  $i$  个年龄组的组距
  - $p_i$  第  $i$  年龄组的年龄别率
1. 作为一种直接标准化发病率的形式，它可以立即用于不同人群之间的比较；
  2. 可以直观地理解为个体在没有其他竞争风险情况下，到某一特定年龄患癌症的累积风险的近似值。

## 1.9 累积风险

累积率可以通过下面的公式转换为真实的累积风险。

$$\text{累积风险} = 1 - e^{-\text{累积率}}$$

- 虽然累积风险不能给出终生患癌风险的估计，但当将截断的最高年龄组选择为接近该人群平均预期寿命的年龄时，它可被用作该风险的近似值。

## 1.10 当前概率法- Current probability

**当前概率**通过估计**假想出生队列**在其一生中可能发生的癌症数量，可以得到较为现实的终生患癌风险的估计。<sup>5</sup>

$$p = \frac{1}{\ell_0} \sum_{x=1}^g L_x t_x$$

- $p$  发生某癌的概率
- $t_x$  年龄组  $x$  的发病率
- $L_x$  是在假设仅受一般人群死亡率影响的情况下，年龄为  $x$  的幸存者在从  $x$  开始的年龄区间内所生存的年数。
- $\ell_0$  是所考虑的第一个年龄区间开始时该人群的规模。

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<sup>5</sup>Esteve 等（1994）将这种方法称为“当前概率”（current probability）

## 1.11 当前概率法- Current probability

当用于常规发病数据时须基于如下两种假设

- 发病率的分母基于从未患过癌症的个体；
- 另一方面，分子只统计首次癌症病例。

## 1.12 DevCan 方法

SEER 分析程序对当前概率方法的分母进行了调整。

- 软件下载 <https://surveillance.cancer.gov/devcan/download>
- 其方法与当前概率方法的区别仅在于对 5 年年龄组数据的处理方式
- DevCan 假定仅有每位个体的首发原发肿瘤数据可用



## 1.13 AMP 方法

AMP 方法<sup>6</sup>可以解决以下问题：对于登记处无法精确识别同一人群中多个原发肿瘤的情况，或在个体数据不可获得的情况下，该方法能够进行处理。

### /// 适用情况

- 肿瘤登记数据的多原发癌症无法被精确识别
- 肿瘤登记数据个体癌症病例数据不可获得

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<sup>6</sup>多原发癌校正方法，Adjusted for Multiple Primaries

## 1.14 AMP 方法

$$S = \sum_{i=1}^f \frac{R_i}{R_i + M_i - D_i} \hat{S}_0^*(a_i) \times \left\{ 1 - \exp \left( \frac{-w_i}{N_i} (R_i + M_i - D_i) \right) \right\}$$

- $S$  表示被诊断为癌症的概率；
- $M_i$  表示年度死亡人数（全因死亡）；
- $D_i$  表示年度癌症死亡人数（癌症死亡）；
- $R_i$  表示年度（登记的）癌症病例数；
- $N_i$  表示年中人口规模；
- $w_i$  表示第  $i$  个年龄组的宽度；
- $\hat{S}_0^*(a_i)$  表示在年龄  $a_i$  时仍然存活且无癌的概率。

## 1.15 AMP 方法

### /// AMP 方法的假设条件

- 无癌个体的非癌症死亡率与总体人群相同；
- 从未患过癌症的个体，其（新）患癌风险与总体人群相同；
- 如果从未患过癌症，则不可能死于癌症；
- 癌症患者再次患癌的风险与从未患过癌症的人相同；
- 癌症患者与从未患过癌症者死于其他原因（非癌症）的概率相同。

## 1.16 风险的统计学检验

## 2 R 包 ItRISK

## 2.1 安装 R 语言环境

- 下载并安装最新版本的 R([Rhttps://cloud.r-project.org](https://cloud.r-project.org))
- 下载并安装最新版本的 Rstudio(<https://posit.co/download/rstudio-desktop/>)

## 2.2 安装 ltRISK<sup>7</sup>

### 从 github 仓库安装 ltRISK 包

```
install.packages("remotes")  
remotes::install_github("gigu003/ltRISK")
```

### 使用本地安装包安装 ltRISK\_0.1.0.tar.gz

```
install.packages("remotes")  
remotes::install_local("ltRISK_0.1.0.tar.gz")
```

### 加载 ltRISK 包

```
library("ltRISK")
```

---

<sup>7</sup>我们编写了 R 语言包 ltRISK 实现 AMP 方法估计终生患癌风险

## 2.3 计算累积率和累积风险

`cumurate()`函数和 `cumrisk()`函数分别用于计算累积率和风险

准备数据：人口数和发病数，或直接准备年龄别率

```
# 19个年龄组人口数
pop <- c(20005, 86920, 102502, 151494, 182932, 203107, 240289, 247076, 199665, 163820,
145382, 86789, 69368, 51207, 39112, 20509, 12301, 6586, 1909)

# 19个年龄组发病数
inci <- c(156, 58, 47, 49, 48, 68, 120, 162, 160, 294, 417, 522, 546, 628, 891, 831, 926,
731, 269)

# 年龄别率
mx <- inci / pop
```



## 2.4 计算累积率和累积风险

```
# 计算0-74岁累积率  
r1 <- cumrate(mx, eage = 70)  
r1
```

```
Cumulative Rate(1/1)  
0.49771
```

```
# 计算0-69岁累积率  
r2 <- cumrate(mx, eage = 65)  
r2
```

```
Cumulative Rate(1/1)  
0.29511
```

## 2.5 计算累积率和累积风险

```
# 将累积率转换为累积风险
```

```
cumrisk(r1, mp = 100, decimal = 2)
```

```
Cumulative Risk (1/100)
```

```
39.21
```

```
cumrisk(r2, mp = 100, decimal = 2)
```

```
Cumulative Risk (1/100)
```

```
25.56
```

## 2.6 使用 AMP 方法估计终生患癌风险

### /// 变量和数据格式

分年龄组（5 岁组）癌症发病数(ri)、癌症死亡数(di)、全因死亡数(mi)和人口数(ni)，以及其它分层变量。

	agegrp	ri	di	mi	ni
1	0	9303	3511	60594	73872987
2	5	6887	2801	17718	82029530
3	10	6248	2553	18883	72267070
4	15	8509	3183	28127	78303514
5	20	16961	4960	37493	99425613
6	25	39439	9456	75223	119915673

## 2.7 使用 AMP 方法估计终生患癌风险

`ltr` 函数可以估计终生风险，返回结果是一个包含三个元素的列表，包括年龄组、年龄条件概率(`si`)和各年龄组方差(`vari`)。

```
# mi      各年龄组年度全因死亡数
# di      各年龄组年度癌症死亡数
# ri      各年龄组年度癌症诊断数
# ni      各年龄组年度风险人口数
# age_width 年龄组组距
# type    字符型，值为 "developing" or "dying" 表示估计发病风险或死亡风险。

ltr(mi, di, ri, ni, age_width = 5, type = "developing")
```

## 2.8 使用 AMP 方法估计终生患癌风险

```
ll <- ltr(data$mi, data$di, data$ri, data$ni)
names(ll)
```

```
[1] "age"  "si"   "vari"
```

```
ll$si
```

```
[1] 0.0006282493 0.0004176283 0.0004294403 0.0005387614 0.0008438167
[6] 0.0016212578 0.0028331500 0.0043573780 0.0075126093 0.0112960469
[11] 0.0165544653 0.0229139330 0.0306398664 0.0359062536 0.0391944997
[16] 0.0378315652 0.0301131243 0.0248367124
```

## 2.9 点估计和可信区间

`estimate` 函数计算终生风险的点估计值和 95% 可信区间，当指定起始年龄时，则假定在那个年龄是未患癌且存活，所以估计值为起始年龄至死亡的患癌风险。

`estimate` 函数的参数：

- `x` ‘ltr’ 对象，由 `ltr` 函数生成
- `sage` 起始年龄

使用方法：

```
estimate(x, sage = 0, mp = 100, decimal = 2)
```

## 2.10 点估计和可信区间

`post_ci` 函数把点估计值和可信区间包裹起来。

```
s <- estimate(ll)
post_ci(s)
```

```
[1] "26.85(26.70-27.00)"
```

```
s1 <- estimate(ll, sage = 40)
post_ci(s1)
```

```
[1] "25.68(25.61-25.75)"
```

## 2.11 点估计和可信区间

```
s2 <- estimate(ll, sage = 50)  
post_ci(s2)
```

```
[1] "23.80(23.74-23.86)"
```

```
s3 <- estimate(ll, sage = 60)  
post_ci(s3)
```

```
[1] "19.85(19.81-19.90)"
```

```
s4 <- estimate(ll, sage = 70)  
post_ci(s4)
```

```
[1] "13.20(13.17-13.23)"
```



### 3 基于 Global Cancer Observatory 数据估计患癌风险

## 3.1 ItRISK 包内置数据集 GCO\_Today

ItRISK 内置了一个数据集([GCO\\_Today](#))包含 2022 年全球癌症发病数、死亡数、全因死亡数、和 2022 年人口数<sup>8</sup>。

```
# 加载GCO_Today数据集
```

```
data(GCO_Today)
```

```
# 显示TCO_Today数据集变量名
```

```
names(GCO_Today)
```

```
[1] "region" "cancers" "sex"      "age"      "inci"     "mort"     "death"
```

```
[8] "pop"
```

---

<sup>8</sup>数据来源: Global Cancer Observatory Today, and the World Population Prospects 2022

### 3.2 ItRISK 包内置数据集 GCO\_Today

```
head(GCO_Today)
```

```
# A tibble: 6 × 8
```

	region	cancers	sex	age	inci	mort	death	pop
	<chr>	<int>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<int>
1	Australia/New Zealand	1	1	0	0	0	632	930933
2	Australia/New Zealand	1	1	1	0	0	73	993835
3	Australia/New Zealand	1	1	2	0	0	99	1001248
4	Australia/New Zealand	1	1	3	1	0	364	949610
5	Australia/New Zealand	1	1	4	4	0	589	1019806
6	Australia/New Zealand	1	1	5	12	0	752	1169165

```
# Use ?GCO_Today to see the detailed description of GCO_Today dataset.
?GCO_Today
```

### 3.3 ItRISK 包内置数据集 GCO\_Today

GCO\_Today 是一个包含 40,824 行和 8 个变量的数据框，如使用，请引用。

表 4 GCO\_Today 示例数据集变量介绍

Variable name	Type	Description
region	Character	The regions are classified into 20 geographic areas as defined by the United Nations Population Division.
cancers	Integer	Cancers include the code of cancer sites which is the same as cancer dictionary in the GLOBOCAN database.
sex	Integer	Sex code, 1 for male, 2 for female, 3 for total.
age	Integer	The ages are grouped into 5-year intervals, where 0, 1, 2, 3, ..., 17 represent the 0-4, 5-9, 10-14, 15-19, ..., and 85+ age groups, respectively.
inci	Integer	Number of (registered) cancer cases.
mort	Integer	Number of cancer deaths (cancer mortality).
death	Integer	Number of deaths (all-cause mortality).
pop	Integer	The size of the mid-year population.

## 3.4 估计年龄条件概率

```
library(ltRISK)
library(dplyr)
data(GCO_Today)
data <- GCO_Today |>
  filter(region == "World", cancers == 39) |>
  mutate(sex = factor(sex, levels= c(1, 2, 3), labels = c("Male", "Female", "Total"))) |>
  group_by(sex)
model <- data |>
  reframe(model_develop = list(ltr(death, mort, inci, pop, type = "developing")),
          model_dying = list(ltr(death, mort, inci, pop, type = "dying"))
  )
```

## 3.5 估计年龄条件概率

```
model$model_develop[[1]]
```

```
$age
```

```
[1] 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
```

```
$si
```

```
[1] 0.0006451535 0.0004885180 0.0004816078 0.0005774606 0.0007812455
```

```
[6] 0.0012558958 0.0018863017 0.0026858277 0.0042788911 0.0072884901
```

```
[11] 0.0130064996 0.0196248331 0.0295701570 0.0376395945 0.0407228256
```

```
[16] 0.0383286564 0.0290418626 0.0278566411
```

```
$vari
```

```
[1] 4.162422e-07 5.216538e-11 1.249082e-10 5.752388e-11 5.298314e-11
```

```
[6] 1.345461e-10 2.526803e-10 3.535544e-10 5.925897e-10 1.049516e-09
```

```
[11] 1.698918e-09 1.958084e-09 2.333881e-09 2.225952e-09 1.846702e-09
```

```
[16] 1.520990e-09 9.331459e-10 3.543868e-10
```

```
attr(,"class")  
[1] "ltr"
```

## 3.6 估计终生患癌风险

/// 代码和结果

```
res <- model |>
  mutate(lr_developing = post_ci(estimate(model_develop)),
         lr_dying = post_ci(estimate(model_dying)))
res
```

```
# A tibble: 3 × 5
  sex      model_develop model_dying lr_developing      lr_dying
<fct> <list>      <list>      <chr>          <chr>
1 Male  <ltr>        <ltr>        25.62(25.49-25.74) 15.85(15.80-15.90)
2 Female <ltr>        <ltr>        23.91(23.80-24.02) 13.10(13.06-13.14)
3 Total <ltr>        <ltr>        24.81(24.69-24.92) 14.50(14.45-14.54)
```



## 3.7 估计从年龄 X 至死亡的患癌风险

```
res <- model |>
  mutate(lr_deve_40 = post_ci(estimate(model_develop, sage = 40)),
         lr_deve_50 = post_ci(estimate(model_develop, sage = 50)),
         lr_deve_60 = post_ci(estimate(model_develop, sage = 60)),
         lr_deve_70 = post_ci(estimate(model_develop, sage = 70)),
         lr_deve_80 = post_ci(estimate(model_develop, sage = 80))
  ) |>
  select(-model_develop, -model_dying)
res
```

```
# A tibble: 3 × 6
  sex      lr_deve_40      lr_deve_50      lr_deve_60  lr_deve_70  lr_deve_80
<fct> <chr>      <chr>      <chr>      <chr>      <chr>
1 Male  24.74(24.71-24.76) 23.58(23.56-23.60) 20.32(20.3... 13.59(13.5... 5.69(5.68...
2 Female 22.39(22.35-22.42) 20.19(20.16-20.22) 16.42(16.4... 11.29(11.2... 5.57(5.56...
3 Total  23.61(23.59-23.63) 21.95(21.93-21.96) 18.43(18.4... 12.50(12.5... 5.65(5.64...
```

## 4 全球和不同地区终生患癌风险

## 4.1 终生患癌风险

/// 4.1.a 代码和结果

```
data(GCO_Today)
data <- GCO_Today |>
  filter(cancers == 39) |>
  mutate(sex = factor(sex, levels= c(1, 2, 3), labels = c("Male", "Female", "Total"))) |>
  group_by(region, sex)
model <- data |>
  reframe(model_develop = list(ltr(death, mort, inci, pop, type = "developing")),
          model_dying = list(ltr(death, mort, inci, pop, type = "dying")))
```

## 4.2 终生患癌风险

/// 4.2.a 代码和结果

```
res1 <- model |>
  mutate(ltr1 = post_ci(estimate(model_develop)),
         ltr2 = post_ci(estimate(model_develop, sage = 40)),
         ltr3 = post_ci(estimate(model_develop, sage = 50)),
         ltr4 = post_ci(estimate(model_develop, sage = 60)),
         ltr5 = post_ci(estimate(model_develop, sage = 70)),
         ltr6 = post_ci(estimate(model_develop, sage = 80))) |>
  select(-model_develop, -model_dying)
```

## 4.3 终生患癌风险

表 5 展示了不同性别人群终生患癌风险。

```
res1 |>
  filter(region == "World") |>
  select(-region) |>
  flextable() |>
  set_header_labels(values = c("Sex", "Birth-death", "40-death",
                                "50-death", "60-death", "70-death",
                                "80-death")) |>
  width(j = 2:7, width = 1.5) |>
  fontsize(size = 14) |>
  theme_apapa()
```

表 5 全球不同性别人群终生患癌风险

Sex	Birth-death	40-death	50-death	60-death	70-death	80-death
Male	25.62(25.49-25.74)	24.74(24.71-24.76)	23.58(23.56-23.60)	20.32(20.30-20.33)	13.59(13.58-13.61)	5.69( 5.68- 5.70)
Female	23.91(23.80-24.02)	22.39(22.35-22.42)	20.19(20.16-20.22)	16.42(16.40-16.44)	11.29(11.27-11.30)	5.57( 5.56- 5.57)
Total	24.81(24.69-24.92)	23.61(23.59-23.63)	21.95(21.93-21.96)	18.43(18.42-18.45)	12.50(12.49-12.51)	5.65( 5.64- 5.65)

## 4.4 终生患癌风险

表 6 展示了全球不同地区人群终生患癌风险。

```
res1 |>
  filter(!region == "World", sex == "Total") |>
  select(-sex) |>
  flextable() |>
  set_header_labels(values = c("Sex", "Birth-death", "40-death",
                               "50-death", "60-death", "70-death",
                               "80-death")) |>
  width(j = 2:7, width = 1.25) |>
  width(j = 1, width = 2) |>
  theme_report()
```

表 6 全球不同地区人群终生患癌风险

Sex	Birth-death	40-death	50-death	60-death	70-death	80-death
Australia/New Zealand	58.52(57.74-59.29)	55.48(54.99-55.98)	50.78(50.37-51.18)	41.47(41.15-41.79)	27.56(27.33-27.79)	13.08(12.97-13.20)
Caribbean	26.34(26.01-26.66)	25.10(24.83-25.36)	23.64(23.40-23.88)	20.21(20.02-20.40)	14.20(14.07-14.33)	7.12( 7.04- 7.19)
Central America	18.46(18.23-18.69)	17.15(17.04-17.26)	15.86(15.76-15.97)	13.34(13.26-13.42)	9.10( 9.04- 9.16)	4.26( 4.23- 4.30)
Eastern Africa	11.34(11.24-11.44)	10.21(10.16-10.26)	8.95( 8.90- 9.00)	6.84( 6.80- 6.88)	3.85( 3.82- 3.88)	1.23( 1.22- 1.25)
Eastern Asia	32.31(32.17-32.45)	30.71(30.65-30.78)	28.56(28.50-28.61)	24.30(24.25-24.34)	17.10(17.07-17.12)	8.28( 8.26- 8.29)
Eastern Europe	26.00(25.77-26.23)	24.42(24.34-24.50)	22.24(22.17-22.31)	17.34(17.29-17.39)	9.45( 9.42- 9.48)	2.74( 2.73- 2.75)
Melanesia	17.74(17.26-18.22)	16.63(16.19-17.07)	14.84(14.45-15.22)	11.51(11.20-11.83)	6.61( 6.38- 6.84)	2.19( 2.06- 2.32)
Micronesia/Polynesia	31.07(27.07-35.06)	30.16(26.46-33.86)	28.30(25.08-31.52)	23.89(21.31-26.46)	16.48(14.75-18.21)	7.67( 6.82- 8.52)
Middle Africa	8.65( 8.55- 8.76)	7.84( 7.78- 7.90)	6.85( 6.79- 6.90)	5.24( 5.19- 5.29)	2.89( 2.85- 2.92)	0.82( 0.80- 0.84)
Northern Africa	16.99(16.80-17.17)	15.87(15.76-15.98)	14.30(14.21-14.38)	11.36(11.29-11.42)	7.06( 7.02- 7.11)	2.75( 2.73- 2.78)
Northern America	47.68(47.39-47.97)	45.60(45.47-45.73)	42.75(42.64-42.86)	36.29(36.21-36.37)	25.05(24.99-25.11)	12.07(12.05-12.10)
Northern Europe	48.43(47.97-48.89)	46.58(46.29-46.86)	44.08(43.84-44.32)	38.23(38.04-38.41)	27.15(27.02-27.27)	13.17(13.11-13.22)
South America	26.53(26.33-26.73)	25.13(25.04-25.21)	23.48(23.41-23.56)	19.87(19.80-19.93)	13.65(13.61-13.70)	6.48( 6.46- 6.50)
South Central Asia	10.32(10.24-10.41)	9.55( 9.53- 9.57)	8.38( 8.36- 8.40)	6.25( 6.23- 6.26)	3.44( 3.43- 3.45)	1.12( 1.11- 1.12)
South-Eastern Asia	16.76(16.59-16.93)	15.57(15.51-15.62)	13.96(13.91-14.00)	10.95(10.92-10.99)	6.72( 6.70- 6.75)	2.66( 2.65- 2.68)
Southern Africa	14.66(14.52-14.80)	13.47(13.37-13.57)	11.56(11.48-11.65)	8.91( 8.84- 8.99)	4.66( 4.61- 4.70)	1.37( 1.34- 1.39)
Southern Europe	43.02(42.60-43.45)	41.09(40.86-41.32)	38.64(38.45-38.83)	33.18(33.03-33.33)	23.27(23.17-23.37)	11.05(11.01-11.09)
Western Africa	8.22( 8.14- 8.29)	7.51( 7.47- 7.55)	6.61( 6.57- 6.65)	4.95( 4.92- 4.98)	2.65( 2.63- 2.67)	0.66( 0.65- 0.67)
Western Asia	23.77(23.55-23.99)	22.58(22.44-22.72)	21.13(21.01-21.26)	17.91(17.81-18.01)	11.89(11.83-11.96)	5.30( 5.26- 5.34)
Western Europe	47.70(47.35-48.06)	45.85(45.64-46.06)	43.38(43.21-43.55)	37.69(37.56-37.83)	26.84(26.75-26.93)	12.90(12.87-12.94)



## 4.5 全球终生癌症死亡风险

```
res2 <- model |>
  mutate(ltr1 = post_ci(estimate(model_dying)),
         ltr2 = post_ci(estimate(model_dying, sage = 40)),
         ltr3 = post_ci(estimate(model_dying, sage = 50)),
         ltr4 = post_ci(estimate(model_dying, sage = 60)),
         ltr5 = post_ci(estimate(model_dying, sage = 70)),
         ltr6 = post_ci(estimate(model_dying, sage = 80))) |>
  select(-model_develop, -model_dying)
```

## 4.6 全球终生癌症死亡风险

表 7 展示了不同性别人群全球终生癌症死亡风险。

```
res2 |>
  filter(region == "World") |>
  select(-region) |>
  flextable() |>
  set_header_labels(values = c("Sex", "Birth-death", "40-death",
                               "50-death", "60-death", "70-death",
                               "80-death")) |>
  width(j = 2:7, width = 1.5) |>
  theme_apapa()
```

表 7      全球终生癌症死亡风险

Sex	Birth-death	40-death	50-death	60-death	70-death	80-death
Male	15.85(15.80-15.90)	15.52(15.51-15.54)	14.98(14.97-15.00)	13.34(13.33-13.36)	9.85( 9.84- 9.86)	5.04( 5.03- 5.04)
Female	13.10(13.06-13.14)	12.71(12.69-12.73)	12.04(12.03-12.06)	10.64(10.62-10.65)	8.20( 8.19- 8.21)	4.70( 4.70- 4.71)
Total	14.50(14.45-14.54)	14.14(14.13-14.15)	13.54(13.53-13.55)	12.01(12.00-12.02)	9.04( 9.03- 9.04)	4.87( 4.86- 4.87)

## 4.7 全球终生癌症死亡风险

表 8 展示了全球不同地区人群终生癌症死亡风险。

```
res2 |>
  filter(!region == "World", sex == "Total") |>
  select(-sex) |>
  #head(n=15) |>
  flextable() |>
  set_header_labels(values = c("Sex", "Birth-death", "40-death",
                                "50-death", "60-death", "70-death",
                                "80-death")) |>
  width(j = 2:7, width = 1.25) |>
  width(j = 1, width = 2) |>
  theme_report()
```

表 8 全球不同地区人群终生癌症死亡风险

Sex	Birth-death	40-death	50-death	60-death	70-death	80-death
Australia/New Zealand	25.89(25.43-26.34)	25.68(25.24-26.11)	25.27(24.86-25.69)	23.92(23.56-24.28)	20.61(20.35-20.87)	14.10(13.95-14.24)
Caribbean	17.94(17.76-18.12)	17.54(17.37-17.71)	16.94(16.78-17.10)	15.38(15.24-15.52)	12.26(12.15-12.38)	7.38( 7.30- 7.46)
Central America	10.73(10.64-10.82)	10.33(10.26-10.39)	9.86( 9.79- 9.92)	8.77( 8.71- 8.83)	6.63( 6.58- 6.68)	3.50( 3.47- 3.53)
Eastern Africa	8.55( 8.49- 8.62)	7.94( 7.89- 7.98)	7.16( 7.12- 7.20)	5.64( 5.61- 5.68)	3.36( 3.33- 3.38)	1.15( 1.14- 1.17)
Eastern Asia	21.27(21.22-21.33)	21.00(20.95-21.04)	20.44(20.40-20.48)	18.81(18.77-18.84)	14.98(14.96-15.01)	8.66( 8.64- 8.67)
Eastern Europe	14.69(14.62-14.75)	14.37(14.32-14.41)	13.64(13.59-13.68)	11.41(11.38-11.45)	7.16( 7.14- 7.19)	2.62( 2.61- 2.63)
Melanesia	12.13(11.79-12.46)	11.68(11.36-12.00)	10.84(10.54-11.15)	9.00( 8.72- 9.27)	5.82( 5.59- 6.04)	2.22( 2.08- 2.36)
Micronesia/Polynesia	21.77(18.85-24.68)	21.68(18.77-24.59)	21.03(18.29-23.77)	18.67(16.43-20.91)	13.97(12.43-15.52)	7.54( 6.65- 8.42)
Middle Africa	6.46( 6.39- 6.53)	6.01( 5.95- 6.06)	5.37( 5.33- 5.42)	4.24( 4.20- 4.29)	2.48( 2.44- 2.51)	0.78( 0.76- 0.80)
Northern Africa	12.45(12.35-12.55)	12.04(11.96-12.12)	11.32(11.25-11.39)	9.63( 9.57- 9.68)	6.76( 6.71- 6.81)	3.20( 3.17- 3.24)
Northern America	18.95(18.88-19.02)	18.71(18.65-18.77)	18.30(18.24-18.35)	16.90(16.85-16.96)	13.82(13.78-13.86)	8.87( 8.84- 8.89)
Northern Europe	25.93(25.71-26.16)	25.73(25.53-25.93)	25.30(25.11-25.49)	23.86(23.70-24.03)	20.04(19.92-20.16)	12.53(12.47-12.59)
South America	15.47(15.39-15.54)	15.07(15.02-15.12)	14.50(14.45-14.55)	13.02(12.97-13.06)	10.03(10.00-10.07)	5.63( 5.60- 5.65)
South Central Asia	7.23( 7.19- 7.28)	6.88( 6.87- 6.90)	6.24( 6.23- 6.26)	4.81( 4.80- 4.82)	2.80( 2.79- 2.80)	1.01( 1.00- 1.01)
South-Eastern Asia	11.97(11.90-12.05)	11.54(11.50-11.58)	10.75(10.72-10.78)	8.95( 8.92- 8.98)	6.01( 5.99- 6.03)	2.66( 2.65- 2.68)
Southern Africa	9.38( 9.30- 9.46)	8.89( 8.81- 8.96)	8.00( 7.94- 8.07)	6.55( 6.49- 6.61)	3.94( 3.90- 3.99)	1.61( 1.58- 1.63)
Southern Europe	24.78(24.56-25.00)	24.57(24.38-24.75)	24.05(23.88-24.21)	22.30(22.17-22.43)	18.29(18.20-18.38)	11.16(11.12-11.20)
Western Africa	5.88( 5.83- 5.92)	5.49( 5.46- 5.52)	4.93( 4.90- 4.96)	3.84( 3.81- 3.86)	2.20( 2.17- 2.22)	0.60( 0.58- 0.61)
Western Asia	16.52(16.41-16.63)	16.15(16.05-16.24)	15.62(15.53-15.71)	14.03(13.95-14.11)	10.34(10.28-10.40)	5.34( 5.30- 5.38)
Western Europe	25.06(24.88-25.24)	24.85(24.69-25.00)	24.34(24.20-24.48)	22.53(22.41-22.64)	18.46(18.37-18.54)	11.26(11.23-11.30)

# 请 批 评 指 正

Thanks for your attention

## 关注作者 🙄🙄

陈琼博士 副主任医师 河南省癌症中心 | 河南省肿瘤医院



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