

Mortality and life tables

R codes and data for today's class can be obtained as

- <https://minato.sip21c.org/demography-special/deaths.txt>
- <https://minato.sip21c.org/demography-special/code20210520.R> (age-standardization)
- <https://minato.sip21c.org/demography-special/code-chap6.R>
- <https://minato.sip21c.org/demography-special/tables-6.xls>
- <https://minato.sip21c.org/demography-special/answer6c.R> (for Exercises)
- <https://minato.sip21c.org/demography-special/table6c.xls> (for Exercises)

Crude Death Rate (CDR) for general mortality level (but ignoring age structure)

Infant Mortality Rate (IMR) for sanitation level (Pay attention to the difference between the populations of numerator and denominator)

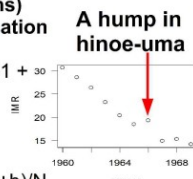
Neonatal Mortality Rate (NMR), Early Neonatal Mortality Rate (ENMR), Stillbirth Rate (SBR) (Note: Pay attention to the definition of stillbirth/spontaneous abortion, in current Japan, 22 weeks as gestational period is critical) and **Perinatal Mortality Rate (PMR)** for medical standards and maternal health level (Note: **Maternal Mortality Ratio (MMR)** is not explained in the text.)

(see, Supplementary material below)

■ **IMR = (No. of death under age 1) / (1000 live births)**

■ **Note: IMR in year x is given by the following equation**

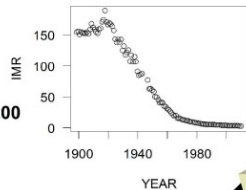
- Death under age 1 in year x
- = (a) Death in year x under age 1 born in year x-1 + (b) Death in year x under age 1 born in year x
- Live births in year x (N)
- = (b) + (c) Survival until age 1 + (d) Death in year x+1 under age 1
- IMR in year x should be (b+d)/N, but given by (a+b)/N assuming (a) nearly equals (d) in a large population.
- A hump in hinoe-uma is mainly caused by (d)<(a).



■ **Reflecting sanitary condition and living standards**

■ **International comparison**

- Japan: 2.4, one of the lowest countries
- Library (fmsb)
- plot(IMR ~ YEAR, data=Jvital)
- Very high in Sub-Sahel African countries
- Siella-Leone, Angola, Niger, Liberia: >200



■ **Top share cause of IM in Japan**

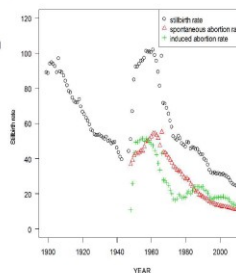
- Injury at delivery during 1979-1984
- Congenital abnormalities since 1985

■ In the Newell's textbook, the term "Late Foetal Death Rate" is used as its synonym.

■ **Fetal deaths (the criteria are different by time/region)**

- Early fetal death (miscarriage): before 20 wks
- Intermediate fetal death: 20-28 wks
- Late fetal death (stillbirth): after 28wks
- WHO's recommendation in 1995: stillbirth is fetal death with body weight>500g and/or after 22wks of gestation (with no vital sign after delivery).
- Japan's criteria: 28wks until 1994, 22wks since 1995 (adopted ICD-10). Stillbirths after 12wks of gestation must be registered.

- When you see the changes of SBR in Japan, you must pay attention to this change of criteria and the progresses of OB-GYN (eg. NICU) and the change of delivery place from home to medical facilities (very drastic after WWII).



■ **SBR = (No. stillbirths) / {(No. stillbirths)+(No. live births)} x 1000**

■ In Japanese statistics, the stillbirth rates for total stillbirth (incl. induced abortion since 1948) and the stillbirth rates for the late fetal death (after 22wks of gestation since 1995, after 28 wks of gestation until 1994) are separately provided.

■ **Definition of toddler death: children's death at ages 1-4**

■ **Toddler MR = (No. death with age 1-4) / (Mid-year population of ages 1-4) * 100000**

- Data in Japan
- 33 in 1999 → 25.4 in 2005 → 22.3 in 2008
- Major causes in Japan
- **Accidental death (esp. by drowning, much more than other developed countries: due to bath?)**
- **Congenital abnormalities**

■ **Under-five MR: integrates IMR and Toddler MR but different**

- Very famous indicator of child health and overall development
- WHO's definition: Probability of a child born in a specific year or period dying before reaching the age of five, if subject to age-specific mortality rates of that period.
- Practical estimation: A probability of death before reaching age 5 *derived from a life table* and expressed as rate per 1,000 live births.

■ **NMR = (No. of deaths under 4 wks) / (1000 live births)**

- Neonatal death = Deaths under 4 wks (28 days, roughly 1 mo.)

■ **The same problem as IMR occurs, but trivial because 4 wks are much shorter than 1 year.**

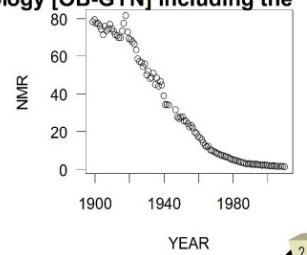
■ **NMR consists of Early NMR (ENMR) and Late NMR.**

- ENMR = (No. of deaths under 1wk) / (1000 live births)
- Late NMR is not popular compared with ENMR.

■ **NMR is largely affected by maternal health status and medical (especially obstetrics and gynecology [OB-GYN] including the NICU facility) level.**

■ **Rapid decline in Japan.**

```
library(fmsb)
plot(NMR ~ YEAR, data=Jvital)
```

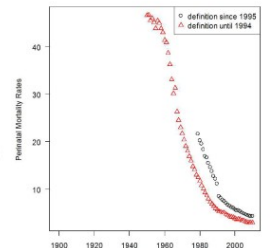


■ **Perinatal death= late fetal death after 28 wks of gestation + early neonatal death under 1 wk**

- Largely affected by maternal health status
- Early neonatal death is sometimes misclassified as stillbirth in developing countries

■ **Definition in Japanese statistics**

- (Perinatal death) = (late fetal death after 22 wks [28 wks until 1994] of gestation)+ (early neonatal death under 1 wk)
- (Perinatal MR)= (No. perinatal death) / {(No. stillbirth after 22 wks of gestation) + (No. live births)} * 1000
- * The denominator of Perinatal MR was No. live births until 1994.



■ **Trends in recent Japan**

```
library(fmsb)
par(mar=c(2,4,3,2), las=1, cex=1.2)
matplot(Jvital$YEAR, cbind(Jvital$PNMFB, Jvital$PNMPLB),
pch=1:2, col=1:2, ylab="Perinatal Mortality Rates")
legend("topright", pch=1:2, col=1:2,
legend=c("definition since 1995", "definition until 1994"))
```

■ **Maternal death**

- Concept: woman's death caused by the diseases or abnormalities directly related to pregnancy, delivery or puerperia
- WHO's definition: the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes

■ **Maternal Mortality Ratio (because denominator does not include numerator) = No. Maternal death / 100000 live births (or 100000 total births)**

- In Japan, the term "Maternal Mortality Rate" is used
- = No. Maternal death / (No. live births + No. stillbirths after 22 wks) * 100000

■ **International comparison**

- Some countries in Sub-Sahara or South Asia, several hundreds
- Japan and West Europe since 1990, less than 10
- USA: <10 in 1980s-1990s, 13.3 in 2003, 17.0 in 2004, 18.4 in 2005

■ **Trend and major causes in Japan**

- Rapid decline: 130.6 (in 1960), 52.1 (in 1970), 20.5 (in 1980), 8.6 (in 1990), 6.1 (in 1999), 4.8 (in 2006), 3.1 (in 2007), 3.5 (in 2008), 4.8 (in 2009), 4.1 (in 2010), 3.8 (in 2011)
- Major causes: Haemorrhage, Pregnancy Induced Hypertension (PIH; recently declined in Japan), Obstetric Venous Thromboembolism (VTE; slowly declined, thus the share is increasing in Japan)

Explanation for "Specific Death Rates" and "Standardization": As Sweden and Kazakhstan's population and death data by age show, CDR is largely affected by age-structure and ASDRs are difficult to see (the meaning of many values are not clear).

Age-standardized mortality rates are useful (amongst, SMR is an important measure, especially for developing countries with poor data quality).

Age standardization

- Direct method
 - ASDR (Death at age x per population at age x) in target population: $Dt(x)$
 - Reference (standard) population for each age: $SP(x)$
 - Total reference population: $SP = \sum SP(x)$
 - age-adjusted (direct) mortality rate = $\sum(Dt(x)*SP(x)) / SP$
- Indirect method
 - ASDR (Death at age x per population at age x) in reference (standard) population: $Ds(x)$
 - Total number of death in target population: TD
 - Target population for each age: $TP(x)$
 - CDR in reference population: $CDRs$
 - $SMR = TD / \sum(Ds(x)*TP(x))$
 - age-adjusted (indirect) mortality rate = $SMR*CDRs$

Example of age standardization

- `sk <- read.delim("http://minato.sip21c.org/demography-special/deaths.txt")`
- Reference (standard) population for each age group (STP) is necessary, so that it's given as `STP <- (sk$NSW+sk$SK)/2`
- Standard ASDR (ASDRST) is got by `STD <- (sk$DSW+sk$SDK)/2`; `ASDRST <- STD/STP`
- Sweden's ASDR (ASDRSW) is got by `ASDRSW <- skDSW/skNSW`
- Direct method: `sum(ASDRSW*STP)/sum(STP)`
- Indirect method: `(sum(sk$DSW)/sum(sk$NSW*ASDRST))*(sum(STD)/sum(STP))`

sk\$NSW

AG	NSW	DSK	NK	DK
0	59227	279	174076	3720
"1-4"	22975	42	15476	1220
"5-9"	24512	31	879129	896
"10-14"	240130	33	808510	268
"15-19"	264957	61	720161	561
"20-24"	281126	87	622988	673
"25-29"	311111	98	73057	752
"30-34"	288961	140	722212	865
"35-39"	268306	137	612925	1113
"40-44"	308238	202	487866	1405
"45-49"	320172	543	284789	1226
"50-54"	242231	738	503008	2078
"55-59"	218795	972	301379	3266
"60-64"	218058	1840	374517	5212
"65-69"	224475	2752	29247	8988
"70-74"	22252	4969	154023	8162
"75-79"	184102	6145	143817	8199
"80-84"	140867	9587	88716	3013
"85+"	110242	17340	58340	10627

Table 6-2. Life table for California 1970

Age interval x to x+1	Mid-year Population (Px)	Deaths in year (Dx)	ASDR (Mx) = Dx/Px	Fraction of last year lived (ax)	Probability of dying (qx) = Dx / (Px + (1-ax)*Dx) = Mx / (1+(1-ax)*Mx)
0	340483	6234	0.018309284	0.09	0.018009224
1	326154	368	0.001128301	0.43	0.001127576
2	312699	269	0.000860252	0.45	0.000859845
3	323441	237	0.000732746	0.47	0.000732461
4	338904	175	0.00051637	0.49	0.000516234
5	362161	179	0.000494255	0.5	0.000494133
6	379642	171	0.000450424	0.5	0.000450323
...
83	34439	3753	0.10897529	0.5	0.103344302
84	31009	3669	0.118320488	0.5	0.111711602
"85+"	142691	22483	0.157564247	---	1

Table 6-3. Abridged life table for England and Wales, females 1985

x	n	ASDR (nMx)	nax = n*Mx / (1+n*(1-max)*nMx)	npqx = 1-nqx	lx = l(x-1)	lnqx	nLx = n*(l(x+1)+nLx)	Tx =	ex = Tx/lx	
0	1	0.008314	0.1	0.008252	0.991748	100000	825	99257	77.562	
1	4	0.000408	0.4	0.001630	0.998370	99175	162	396311	77.206	
5	5	0.000181	0.5	0.000905	0.999095	99013	90	494842	73.330	
10	5	0.000187	0.5	0.000935	0.999065	98924	92	494386	68.394	
15	5	0.000282	0.5	0.001409	0.998591	98831	139	493807	63.455	
20	5	0.000307	0.5	0.001534	0.998466	98692	151	493080	58.541	
25	5	0.000364	0.5	0.001818	0.998182	98540	179	492254	53.628	
30	5	0.000566	0.5	0.002826	0.997174	98361	278	491111	48.721	
35	5	0.000884	0.5	0.004410	0.995590	98083	433	489335	43.852	
40	5	0.001445	0.5	0.007199	0.992801	97651	703	486496	39.035	
45	5	0.002485	0.5	0.012348	0.987652	96948	1197	481746	34.300	
50	5	0.004210	0.5	0.020831	0.979169	95751	1996	473767	29.697	
55	5	0.007219	0.5	0.035455	0.964545	93756	3324	460470	25.276	
60	5	0.012054	0.5	0.058507	0.941493	90432	5291	438932	21.113	
65	5	0.018259	0.5	0.087310	0.912690	85141	7434	407121	14.70365	
70	5	0.029920	0.5	0.139189	0.860811	77707	10816	361497	10.63244	
75	5	0.049689	0.5	0.220993	0.779007	66891	14783	297500	7.01477	
80	5	0.085545	0.5	0.352367	0.647633	52109	18361	214641	4.04247	
85+		0.177987		1	0	33747	33747	189606	189606	5.618

Lifetable functions are very important in demography. Needed information is basically ASDR (Age Specific Death Rates).

Using fmsb package in R, it's easy to calculate life table as follows (included in code-chap6.R).

library(fmsb)

```
mx <- c(0.008314, 0.000408, 0.000181, 0.000187, 0.000282, 0.000307, 0.000364,
        0.000566, 0.000884, 0.001445, 0.002485, 0.004210, 0.007219, 0.012054,
        0.018259, 0.029920, 0.049689, 0.085545, 0.177987)
```

```
lifetable2(mx, ax=c(0.1, 0.4, rep(0.5, 16), NA), n=c(1, 4, rep(5, 16), NA))
```