Demography Special Lecture (6)   16 May 2024

Mortality and life tables

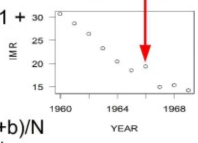
R codes and data for today's class can be obtained as
https://minato.sip21c.org/demography-special/deaths.txt
https://minato.sip21c.org/demography-special/code20210520.R (age-standardization)
https://minato.sip21c.org/demography-special/code-chap6.R
https://minato.sip21c.org/demography-special/tables-6.xls
https://minato.sip21c.org/demography-special/answer6e.R (for Exercises)
https://minato.sip21c.org/demography-special/table6e.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.)

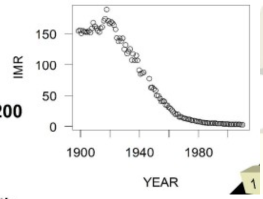
(see, Supplementary material below)

- **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).

A hump in hinoe-uma

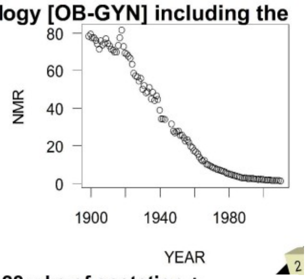


- **Reflecting sanitary condition and living standards**
- **International comparison**
  - Japan: 2.4, one of the lowest countries
    ```
    library(fmsb)
    plot(IMR ~ YEAR, data=Jvital)
    ```
  - Very high in Sub-Sahel African countries
    - **Siella-Leone, Angola, Niger, Liberia: >200**
- **Top share cause of IM in Japan**
  - Injury at delivery during 1979-1984
  - Congenital abnormalities since 1985



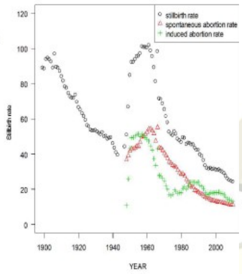
1

- **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)
  ```



2

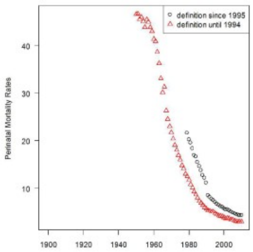
- **In the Newell's textbook, the term "Late Foetal Death Rate" is used as its synonym.**
- **Fetal deaths (the criteria are different by time/region)**
  - Early fetal death (miscarriage): before 20 wks
  - Intermediate fetal death: 20-28 wks
  - Late fetal death (stillbirth): after 28wks
  - WHO's 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.**



3

- **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$YEAR, cbind(Jvital$PNMPB, 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"))
```



4

- **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.

- **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=Σ SP(x)
- age-adjusted (direct) mortality rate = Σ(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/ Σ(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$NSW+sk$NK)/2
- Standard ASDR (ASDRST) is got by STD <- (sk$DSW+sk$DK)/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	DSW	NK	DK
"0"	59727	279	174078	3720
"1-4"	229775	42	754758	1220
"5-9"	245172	31	879129	396
"10-14"	240110	33	808510	298
"15-19"	264957	61	720161	561
"20-24"	287176	87	622988	673
"25-29"	311111	98	733057	752
"30-34"	280991	140	732312	965
"35-39"	286899	197	612825	1113
"40-44"	308239	382	487996	1405
"45-49"	320172	643	284799	1226
"50-54"	242230	738	503808	2878
"55-59"	210785	972	301879	3266
"60-64"	216058	1640	374317	5212
"65-69"	224479	2752	256247	6886
"70-74"	222578	4509	154623	8182
"75-79"	184102	6745	149917	8199
"80-84"	140667	9587	88716	9013
"85+"	110242	17340	58940	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	nqx = n*nMx / (1+n*(1-nax)*nMx)	npx = 1-nqx	lx = l(x-1)-nd(x-1)	ndx = lx*nqx	nLx = n*(l(x+1)+nax*ndx)	Tx = T(x+1)+nLx	ex = Tx/lx
0	1	0.008314	0.1	0.008252	0.991748	100000	825	99257	7756161	77.562
1	4	0.000408	0.4	0.001630	0.998370	99175	162	396311	7656904	77.206
5	5	0.000181	0.5	0.000905	0.999095	99013	90	494842	7260592	73.330
10	5	0.000187	0.5	0.000935	0.999065	98924	92	494386	6765751	68.394
15	5	0.000282	0.5	0.001409	0.998591	98831	139	493807	6271364	63.455
20	5	0.000307	0.5	0.001534	0.998466	98692	151	493080	5777557	58.541
25	5	0.000364	0.5	0.001818	0.998182	98540	179	492254	5284477	53.628
30	5	0.000566	0.5	0.002826	0.997174	98361	278	491111	4792223	48.721
35	5	0.000884	0.5	0.004410	0.995590	98083	433	489335	4301111	43.852
40	5	0.001445	0.5	0.007199	0.992801	97651	703	486496	3811776	39.035
45	5	0.002485	0.5	0.012348	0.987652	96948	1197	481746	3325280	34.300
50	5	0.004210	0.5	0.020831	0.979169	95751	1995	473767	2843534	29.697
55	5	0.007219	0.5	0.035455	0.964545	93756	3324	460470	2369767	25.276
60	5	0.012054	0.5	0.058507	0.941493	90432	5291	438932	1909297	21.113
65	5	0.018259	0.5	0.087310	0.912690	85141	7434	407121	1470365	17.270
70	5	0.029920	0.5	0.139189	0.860811	77707	10816	361497	1063244	13.683
75	5	0.049689	0.5	0.220993	0.779007	66891	14783	297500	701747	10.491
80	5	0.085545	0.5	0.352367	0.647633	52109	18361	214641	404247	7.758
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))
```