HACETTEPE UNIVERSITY INSTITUTE OF POPULATION STUDIES (HUIPS)

DEM 601 Introduction to Demographic Analysis

Formula sheet COVERS lectures 1 to 6 TERM Fall 2026

> **Every equation the course has shown you, in the order it was shown.**

Lecture 1 · Introduction to the Course and Basic Demographic Concepts

$$P_{n+k} = P_n + \underbrace{\underbrace{{}_kB_n - {}_kD_n}_{\text{natural increase}} + \underbrace{{}_kI_n - {}_kE_n}_{\text{net migration}}}_{\text{population change}}$$

What makes a population change

Lecture 2 · Demographic Indicators and Person-Years-Lived

$$\text{indicator} = \frac{\text{numerator}}{\text{denominator}} \times k$$

What an indicator is

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

The mean

$$M = L_0 + \left(\frac{P/2 - \sum f_0}{f_0}\right) i$$

The median of grouped data

$$\text{ratio} = \frac{a}{b} \times k$$

Ratio

$$\text{proportion} = \frac{a}{a+b}$$

Proportion

$$\text{percentage} = \frac{a}{a+b} \times 100$$

Percentage

$$\text{rate} = \frac{e}{PY} \times k$$

A rate needs time

$$CBR = \frac{\text{births in the year}}{\text{mid-year population}} \times 1000$$

Is it a true rate?

$$IMR = \frac{\text{deaths under age 1}}{\text{live births in the year}} \times 1000$$

Is it a true rate?

$$q = \frac{e}{P_0}$$

A rate is not a probability

$$\bar{P} = \frac{P_0 + P_1}{2}$$

The mid-year population

Lecture 3 · Population Change

$$\Delta P = P_t - P_0$$

Absolute change

$$\%\Delta P = \frac{P_t - P_0}{P_0} \times 100$$

Percentage change

$$P_n = P_0 + \big(n \times (r \times P_0)\big)$$

Arithmetic growth

$$r = \frac{P_n - P_0}{n} \div P_0 \times 100$$

Arithmetic growth

$$P_n = P_0 \times (1 + r)^n$$

Geometric growth

$$r = \sqrt[n]{\frac{P_n}{P_0}} - 1$$

Geometric growth

$$P_n = P_0 \times e^{r \times n}$$

Exponential growth

$$r = \frac{\ln(P_n / P_0)}{n}$$

Exponential growth

$$r(t) = \lim_{\Delta t \to 0} \frac{\Delta N(t)}{N(t)\,\Delta t} = \frac{\frac{dN(t)}{dt}}{N(t)} = \frac{d\ln[N(t)]}{dt}$$

Exponential growth

$$P_n = P_0 \times e^{r \times n}$$

Running the formula forwards

$$2P_0 = P_0 \times e^{r \times n}$$

How long until twice as many?

$$\ln(2) = r \times n$$

How long until twice as many?

$$n = \frac{\ln(2)}{r}$$

How long until twice as many?

$$\text{Population Turnover} = \text{Losses} + \text{Gross Growth}$$

Standing still is work

Lecture 4 · Age and Sex Composition

$$SR = \frac{P^m}{P^f} \times 100$$

Men per hundred women

$$SR_x = \underbrace{SRB}_{\text{where the cohort began}} \times \underbrace{\frac{S_x^m}{S_x^f}}_{\text{surviving to age } x} \times \underbrace{M_x}_{\text{net migration}}$$

Three things move it

$$\text{Child} = \frac{P_{\text{0-14}}}{P_{\text{15-64}}} \times 100$$

Four ratios from three numbers

$$\text{Elderly} = \frac{P_{65+}}{P_{\text{15-64}}} \times 100$$

Four ratios from three numbers

$$\text{General} = \text{Child} + \text{Elderly}$$

Four ratios from three numbers

$$\text{Aging index} = \frac{P_{65+}}{P_{\text{0-14}}} \times 100$$

Four ratios from three numbers

$$f = \frac{\text{total}}{\text{of known age}}$$

Putting back the ages nobody wrote down

$$W = 100 \times \frac{5\left(P_{25} + P_{30} + \cdots + P_{60}\right)}{P_{23} + P_{24} + \cdots + P_{62}}$$

Whipple's index

$$ID = \tfrac{1}{2}\sum_i \left|a_i - b_i\right|$$

The index of dissimilarity

Lecture 5 · Measures of Mortality

$$CDR = \frac{D}{PY} \times 1000$$

Deaths per thousand people

$$ {}_nm_x \;=\; \frac{{}_nD_x}{{}_nPY_x} \times 1000 $$

One age at a time

$$ q_x \;=\; \frac{2m_x}{2+m_x} \qquad {}_nq_x \;=\; \frac{2n\cdot {}_nm_x}{2+n\cdot {}_nm_x} $$

From one to the other

$$ \text{share}_c \;=\; \frac{D_c}{D}\times 100 \qquad \text{rate}_c \;=\; \frac{D_c}{PY}\times 100{,}000 $$

A share is not a risk

Lecture 6 · Standardization of Death Rates & Concepts in Early Life Mortality

$$ \text{CDR} \;=\; \sum_x {}_nm_x \cdot {}_nc_x $$

A summary rate is rates times weights

$$ {}_nm_x = \frac{{}_nD_x}{{}_nP_x} \qquad {}_nc_x = \frac{{}_nP_x}{P},\quad \sum_x {}_nc_x = 1 $$

A summary rate is rates times weights

$$ \text{ASDR}^{\,j} \;=\; \sum_x {}_nm_x^{\,j}\cdot {}_nc_x^{\,s} \qquad {}_nm_x^{\,j} \text{ is population } j\text{'s own rate},\quad {}_nc_x^{\,s} \text{ the standard's share} $$

Somebody else's people, your own rates

$$ \text{SMR} \;=\; \frac{D^{\,j}}{\sum_x {}_nm_x^{\,s}\cdot {}_nP_x^{\,j}}\times 100 \qquad \text{ISDR} \;=\; \frac{\text{SMR}}{100}\times \text{CDR}^{\,s} $$

Your own people, somebody else's rates

$$ \text{IMR} \;=\; \frac{\text{deaths under age 1 in year } t}{\text{live births in year } t}\times 1000 $$

Not a population, a cohort of births

$$ \text{rate} \;=\; \frac{\text{deaths in the year, at the ages below}}{\text{live births in the same year}}\times 1000 $$

Every rate over live births

$$\text{stillbirth rate} = \frac{\text{stillbirths, from 28 weeks of pregnancy}}{\text{live births} + \text{stillbirths}} \times 1000$$

Two rates over all births

$$\text{perinatal rate} = \frac{\text{stillbirths} + \text{deaths at 0 to 6 days}}{\text{live births} + \text{stillbirths}} \times 1000$$

Two rates over all births