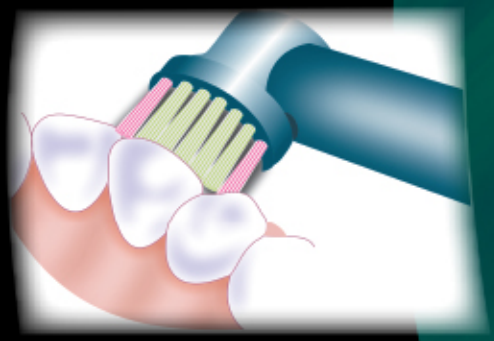


A Textbook of PUBLIC HEALTH DENTISTRY



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Contents

SECTION 1: PUBLIC HEALTH

1. Changing Concepts of Health and Prevention of Disease 3
CM Marya

Determinants of Health 3
Theories of Disease Causation 4
Levels or Categories of Prevention 6
Levels of Prevention 6
Approaches of Prevention 8

2. Basic Epidemiology 9
Abdul Rashid Khan, KA Narayan

Introduction to Epidemiology 9
Measuring Health 11
Epidemiological Studies 13
Screening 20
Association and Causation 21

3. Biostatistics 23
KA Narayan, Abdul Rashid Khan

Why Learn Statistics? 23
How Data is Collected? 24
Data Display and Summary 24
Data Summary 26
Statistical Distributions 28
Chi Square Distribution 29
Tests of Significance 29
Statistical Significance 30
Sampling 31

4. Environment and Health 34
CM Marya

Water Quality—Criteria and Standards 39
Hardness of Water 42
Special Treatment of Water 43
Air 43
Noise 44

Radiation 45
Housing 46
Waste Management 47

5. Organization of the Health System in India 49
CM Marya

Voluntary Health Agencies in India 50
Indian Council for Child Welfare (ICCW) 50
Family Planning Association of India 51
Nutrition Foundation of India 51
Voluntary Health Association of India (VHAI) 51
The Kasturba Gandhi Trust 51
Action for Autism 52
Ajit Foundation 52
Chethana 52
All India Women's Conference (AIWC) 52
Pragati 52
The Hind Kusht Nivaran Sangh 52

6. Primary Health Care 55
CM Marya

Concept of Primary Health Care 55
Origin of Primary Health Care 55
Alma-Ata 56
Components of Primary Health Care 56
Declaration of Alma-Ata 58

7. Health Agencies of the World 61
CM Marya

International Red Cross and Red Crescent Movement 62
CARE USA 62
Refugee and Disaster Relief Organizations 63
WHO (World Health Organization) 63
PAHO (The Pan, American Health Organization) 66
FAO (The Food and Agriculture Organization) 67
UNDP (The United Nations Development Program) 68
PAHEF (The Pan-American Health and Education Foundation) 68
ICRC (International Committee of the Red Cross) 69
The World Bank 70
UNFPA (United Nations Population Fund) 70
CARE (Cooperative for American Relief Everywhere) 72
The Rockefeller Foundation [RF] 72
The Ford Foundation 73
World Health Days 73
Important Dates – World Health 74

8. Nutrition and Health 75
RK Marya

The Basal Energy Requirement 75
Physical Work 75
Total Caloric Requirements 75
Minerals 79
Fat Soluble Vitamins 79
Water Soluble Vitamins 81

Disorders of Malnutrition (Undernutrition) 82
Disorders of Overnutrition 84

SECTION 2: DENTAL PUBLIC HEALTH

9. Introduction to Public Health Dentistry 87
CM Marya

Definitions of Public Health 87
Essential Public Health Services 88
Concepts of Public Health 88
Public Health Problem 88
Impact of Oral Disease 88
Milestones in Dental Public Health 90
Historical Overview 90
Aims of Dental Public Health 92
Tools of Dental Public Health 93
Procedural Steps in Dental Public Health 93
Functions of Public Health Dentistry 95
Public Health Milestones in Independent India 95

10. Epidemiology of Dental Caries 98
CM Marya

Definition 98
Epidemiology 98
Trends in Dental Caries 100
Reasons for Caries Decline and Rise 100
Dental Caries Pandemic 100
Caries Incidence in Europe 100
Caries Incidence in the United States 100
Indian Scenario 100
Dental Caries in Underdeveloped Countries 101
Probable Reasons for the Marked Decline in Dental Caries in Most Western Industrialized Countries 101
The Caries Process (Pathogenesis) 102
Theories of Dental Caries 103
Areas Prone to Dental Caries 104
Importance of Diagnosis of Dental Caries 104
Classification of Dental Caries 104
Enamel Changes During Early Caries Lesion Development 105
Changes Recorded in Enamel Covered by Dental Plaque 105
Histopathology of Dental Caries 105
Caries of the Enamel 105
Caries of the Dentine 106
Various Zones of Caries of Dentine 107
Caries in Dentine 108
Root Caries 108
Susceptibility of Different Teeth 108
Factors Affecting the Epidemiology of Dental Caries 108
Factors Affecting Development of Dental Caries 109
Host and Teeth Factors 109
Agent Factors 110
Environmental Factors 111
Early Childhood Caries 111
Root Caries 111

11. Epidemiology of Periodontal Disease 114
CM Marya

Disease Process and Changing Concept 114
Epidemiology 114
Prevalence of Gingivitis 114
Prevalence of Periodontitis 115
Causes of Periodontal Disease 116
Risk Factors in Periodontal Disease 117
Structure of the Periodontal Tissues 117
Gingivae 117
Periodontal Ligament 118
The Natural History of Periodontal Disease 118
Periodontitis 119
Classification of Periodontal Disease 119
Determinants of Periodontitis 119

12. Epidemiology, Etiology and Prevention of Oral Cancer 126
CM Marya, Rakesh Dhankar

Incidence 126
In India and Sri Lanka 126
Western Countries 126
Trends 126
Smoked Tobacco 127
Types 127
Constituents of Tobacco Smoke 129
Smokeless Tobacco 130
Alcohol 131
Mouthwash Use 131
Vitamins and Essential Minerals 131
Occupation 131
Sunlight 131
Chemical Agents 131
Potentially Malignant Lesions 131
Viral Infection 132
Trauma 132
Pathogenesis 132
Pathological Types 133
Diagnostic Evaluation 135
Staging 135
The Exam Review 136
The Importance of Early Detection 140
Levels of Prevention of Oral Cancer 140
Public Health Approaches to Prevention of Oral Cancer 142
Tobacco/Smoking Cessation 142

13. Epidemiology and Etiology of Malocclusion 144
Gurkeerat Singh

An Epidemiological View of Malocclusion 144
Classification of Malocclusion 144
Angle's Classification of Malocclusion 144
Dewey's Modification of Angle's Classification of Malocclusion 147
Bennette's Classification of Malocclusion 147

Skeletal Classification 148
Ackerman-Profitt System of Classification 148
Incisor Classification 148
Prevalence of Malocclusion 150
Etiology of Malocclusion 153
Untreated Malocclusions 155

14. Dental Health Education 156
CM Marya

Definition 156
Contents of Health Education 156
Principles of Health Education 157
Models of Health Education 158
Communication 159
Key Elements in Communication 159
Barriers or Road Block of Communication 160
Aids in Health Education 160
Methods in Health Education 161
Steps in Health Education Planning 162
Steps of Learning 163
Various Health Education Methods and Media 163

15. Oral Health Survey Procedures 165
CM Marya

Scientific Method in Conducting a Dental Survey 165
Oral Health Surveys (WHO-1997) 167
Pathfinder Surveys 168
Organizing the Survey 170
Reliability and Validity of Data 170
Implementing the Survey 171
Assessment Form 173
Obtaining Assistance from WHO 181
Post Survey Action and Preparation of Survey Reports 181

16. Dental Indices 185
CM Marya

Definition 185
Properties of an Ideal Index 185
Types of Indices 186
Purpose and Uses of an Index 186
Indices Commonly Used in Dentistry 187
Periodontal Indices 187
Plaque Control Record 188
Navy Plaque Index 188
Oral Hygiene Index (OHI) 189
Patient Hygiene Performance Index (PHP Index) 192
Gingival Index (GI) 193
Calculus Surface Index 193
Periodontal Index (PI) 193
Periodontal Disease Index (PDI) 194
Gingival Bleeding Index (GBI) 195
Papillary-Marginal-Attached Gingival Index 196
Gingival Bone Count Index 197

Community Periodontal Index of Treatmant Needs (CPITN) 197
Community Periodontal Index (CPI) 201
Turesky-Gilmore-Glickman Modification of the Quigley-Hein Plaque Index 202
The Navy Periodontal Disease Index (NPDI) 202
Indices for Dental Caries 204
Decayed, Missing and Filled Teeth (DMFT) Index 204
WHO Modification of DMF Index 205
Dental Caries Index for Deciduous Teeth (dmft and dmfs) 205
Mixed Dentition 206
WHO Index for Dental Caries 206
Significant Caries Index 207
Fluorosis Index 207
Thylstrup-Fejerskov Index of Fluorosis (TF) 208
Tooth Surface Index of Fluorosis (TSIF) 208
Indices for Malocclusion 210
The Index of Orthodontic Treatment Need (IOTN) 210

17. Dental Auxiliaries 212
CM Marya

Dental Team 212
Comprehensive Dental Care 212
Definition 212
Classification 213
Types of Supervision 213
Nonoperating Auxiliaries 214
Operating Auxiliaries 215
Auxiliaries Personnel in India 216
Four-Handed Dentistry 216

18. Finance in Dentistry 218
CM Marya

Preventive and Diagnostic Dental Care 218
Basic Dental Care and Dental Procedures 218
Major Dental Care 218
Common Terms 218
Mechanism of Payment for Dental Care 219
Postpayment Plan 219
Private Third Party Prepayment Plans 219
Reimbursement of Dentists in Prepayment Plans 220
Private Third Party Prepayment Plans 220
Health Maintenance Organization (HMO) 222
Staff Model 222
Group Model 222
Independent Practice Association (IPA) 222
Capitated Network or Direct Contract Model 222
Capitation Plan 222
Public Programs 223
Medicare 223
Medicaid 223

19. Oral Health Promotion 224
CM Marya

Concept of Health 224

Definition of Health Promotion 224
Principles of Health Promotion 224
Oral Health Promotion 225
Strategies of Oral Health Promotion 225
Approaches in Oral Health Promotion 226
Concepts in Health Promotion 226
Elements of Health Promotion 226
Methods of Oral Health Promotion 227
Stages of Behavior Change 227
Goals of Oral Health 228
Global Oral Health Goals 228
National Oral Health Program in India 230
The Magnitude of the Problem 231
Status of Oral Health Care System in India 231
Economic Burden of Oral Diseases 232
Strategies for Implementation 232
Additional Measures Suggested 233
Involvement and Reorientation of the Dentists Working in Urban Areas 234
Implementation of Primary Preventive Package through the School Health Schemes in the Different Urban Areas 234
Reorientation of Dental Education in India 235
Involvement of Other Allied Departments 235
National Institute of Dental Research (NIDR) 235
National Training Center 235

20. Planning and Evaluation 236
CM Marya

Definition 236
Purpose of Planning 236
Uses of Planning 236
Planning Cycle 236
Evaluation 238
Reasons for Evaluation 239

21. School Dental Health Programs 240
CM Marya

Models 240
The Three-Component Model 240
The Eight-Component Model 240
Definition 241
Health Promoting Schools 242
Objectives of School Based Dental Health Program 243
Partners in School Oral Health Programs 243
Self-Applied Fluorides 243
School Based Sealant Program 243
School Water Fluoridation 244
Topical Fluoride Application Program 244
Oral Health Education 244
Guidelines for an Ideal School Dental Program 244
School Dental Health Programs 246
Learning about your Oral Health 246
Tattle Tooth I Program 246
Tattle Tooth II Program 247
Theta Program 247

Yukon Children's Dental Health Program 247
Askov Dental Health Education 248
The Maine School Oral Health Program 248
Elements of School Oral Health Program 248
Some School Based Oral Health Programs in Various Countries 249
Smiling Schools Project in Namibia 250
Dental Public Health Programs in Seychelles 250
School-Based Oral Health Education Program in China 250
School Oral Health Program in Kuwait 251
School Oral Health Program in India 251
Incremental Dental Care 251

22. Dental Council of India 253
CM Marya

Introduction 253
Objectives/Duties 253
Constitution and Composition of Council 254
Incorporation of Council 254
Mode of Election 254
Term of Office and Casual Vacancies 254
President and Vice-President of Council 254
The Executive Committee 255
Recognition of Dental Qualifications 255
Nonrecognition of Dental Qualifications 256
Qualifications of Dental Hygienists 256
Qualifications of Dental Mechanics 256
Effect of Recognition 256
Withdrawal of Recognition 256
Withdrawal of Recognition of Recognized Dental Qualification 256
Professional Conduct 257
The Indian Register 257

23. The Dentist Act of India and Indian Dental Association 258
CM Marya

The Dentists Act (29th March, 1948) 258
Introduction 258
The Dentists (Amendment) Act, 1993 (2nd April, 1993) 259
Indian Dental Association (IDA) 261
Objectives of IDA 261
Types of Membership 262
Head Office 262
State Branch 264

24. Ethics in Dentistry 265
CM Marya

Definition 265
Principles of Ethics 265
Code of Ethics for Dentists by Dental Council of India 267
Duties and Obligation of Dentists towards Patients and Public 267
Duties of One Dentist towards Another 267
Unethical Practices 268
General Principles for a Dental Professional Ethical Code in the Countries of the EU (European Union) 268

SECTION 3: PREVENTIVE DENTISTRY

25. Dental Plaque 273
CM Marya

Formation of Dental Plaque Biofilms 273
Supra and Subgingival Plaque 276
Significance of Dental Plaque 276

26. Plaque Control 277
CM Marya

Definition 277
Guidelines for Acceptance of Chemotherapeutic Products 277
Approaches in Plaque Control 277
Manual Toothbrushes 278
Powered Toothbrushes 279
Sonic and Ultrasonic Toothbrushes 281
Ionic Toothbrushes 281
Bionic Toothbrush—Soladey 281
Toothbrushing Techniques 282
The Bass Method: Sulcular Brushing 282
Modified Bass Technique 283
Stillman's Method 283
Modified Stillman's Technique 284
The Rolling Stroke 284
Charter's Method 284
Circular: The Fones Method 285
Vertical: Leonard Method 285
Physiologic: Smith's Method 285
Interdental Oral Hygiene Aids 285
Dental Floss 286
Floss Holder 288
Toothpicks 288
Interproximal Brushes 289
Single Tuft Brushes 289
Knitting Yarn 290
Gauze Strip 290
Pipe Cleaner 290
Wedge Stimulator 290
Adjunctive Aids 291
Ingredients 292
Abrasives 292
Humectant 293
Water 293
Binding Agent 293
Detergents 293
Flavoring Agent 293
Preservative 293
Therapeutic Agent 293
Sweetening Agents 293
Therapeutic Dentifrices 294
Anticaries 294
Anti-plaque Agents 294

Anticalculus 294
Antihypersensitivity 295
Whitening Agents 295
Disclosing Agents 297
Chemical Plaque Control 298
Vehicles for Delivery of Chemical Agents 298
Antibiotics 299
Enzymes 299
Phenols and Essential Oils 300
Quaternary Ammonium Compounds 301
Bisbiguanide Antiseptics 301
Natural Products 302
Metal Salts 302
Amine Alcohols 302
Fluorides 302
Oral Hygiene Promotion 303
Oral Prophylaxis 304
Steps in Oral Prophylaxis 304

27. Diet and Dental Caries 306
CM Marya

Role of Diet 306
Role of Saliva 307
Caries Mechanism 307
Human Observational Studies 307
Human Interventional Studies 308
Animal Experiment 309
Enamel Slab Experiments 309
Plaque pH Studies 309
Incubation Experiments 309
Evidence 309
The Basic Stephan Curve 310
Stephan Curve: Clinical Relevance 312
Dietary Factor and Dental Caries 312
Cariogenicity of Sugars 313
Carbohydrates and Dental Caries 313
Starches and Dental Caries 314
Fruits and Dental Caries 315
Protective Factors and Caries 315
Effect of Fluoride on Sugar-Caries Relationship 315
Non-sugar Sweeteners and Dental Caries 316
Limitations of Intense Sweeteners 316
Uses of Intense Sweeteners 316
Bulk Sweeteners 316

28. Caries Risk Assessment 317
CM Marya

Goals of Caries Risk Assesment 317
Caries Disease Indicators 317
Caries Risk Factors 318
Caries Protective Factors 318
Factors Relevant to Assessment of Dental Caries 319
Xerostomia 320
Xerostomia and Dental Caries 320

Classification 321
Caries Risk Assessment 321
Factors in Low, Moderate and High Caries Risk Assessment 321
Cariogram 322

29. Caries Activity Tests 324
CM Marya, Vandana Dahiya

Objectives of Caries Activity Tests 324
Advantages of Caries Activity Tests 324
Criteria of an Ideal Caries Activity Tests 324
Caries Activity and Caries Susceptibility 324
Various Caries Activity Tests 325
Streptococcus Mutans Screening Test 328

30. Fluorides in Dentistry 330
CM Marya

History of Water Fluoridation 330
Fluoride in Environment 331
Fluoride in Water and Atmosphere 331
Fluoride in Biosphere 332
Fluoride Metabolism 332
Pharmacokinetics of Fluoride 333
Artificial Fluoridation (Controlled Studies) 334
Effectiveness of Water Fluoridation 335
World Status of Fluoridation 335
Appropriate Levels of Fluoride in Drinking Water 335
Fluoride Compound Used in Water Fluoridation 336
Methods of Water Fluoridation 336
Feasibility of Water Fluoridation in India 337
Mechanism of Action of Fluorides 337
Increased Enamel Resistance 339
Inhibition of Bacterial Enzyme System 340
Increased Rate of Post Eruptive Maturation 340
Enhancing Remineralization 340
Improves Tooth Morphology 341
Fluoride Administration 341
Systemic Fluorides 342
Water Fluoridation 342
Requirements for Water Fluoridation 342
Economics of Fluoridation 342
Medical Aspect of Water Fluoridation 343
Fluoridation and the Law 343
Reasons for Cessation of Fluoridation 344
Ethics of Water Fluoridation 344
Pre-eruptive Effect of Water Fluoridation 344
Water Fluoridation and Root Surface Caries 344
Dietary Supplements 345
Topical Fluorides 348
Advantages and Disadvantages of Topical Fluorides 348
Mechanism of Action 348
Classification 349
Professionally Applied Fluorides [PATF] 349
Clinical Application 351

Fluoride Application Techniques 356
Self Applied Fluorides 358
Fluoride Dentifrices 358
Fluoride Mouthrinses 360
Methods of Preparation 360
Recommendations 360
Advantages 360
Fluoride Exposure from Multiple Sources 360
Evidence in Caries Reduction 361

31. Dental Fluorosis and its Prevention 363
CM Marya

Sources of Fluoride 363
Fluoride Intake 364
Fluoride Toxicity 366
Management of Acute Fluoride Toxicity 367
Lethal and Safe Doses of Fluoride 368
Dental Fluorosis and Enamel Opacities 368
Various Forms of Fluorosis 368
Prevention of Fluorosis 369
Defluoridation of Water 369
Various Methods of Defluoridation of Water 371
Defluoridation of Water Using Nalgonda Technique 373

32. Dental Caries Vaccine 375
Avinash J, CM Marya

History of Vaccination 375
Molecular Pathogenesis of Dental Caries 375
Basic Concepts 376
Different Types of Immunity 376
Vaccines 376
Specific Vaccine Targets 378
Routes of Immunization 378
Common Mucosal Immune System 379
Passive Immunization 380
Active Immunization in Humans 380
Passive Immune Approaches 380
Adjuvants and Delivery Systems for Dental Caries Vaccines 381
Timing and Target Population for Caries Vaccination 382
Recent Advances 382
Risks of Using Caries Vaccine 382
Prospects and Concerns 383
Public Health Aspects 383

33. Pit and Fissure Sealants 384
CM Marya

Classification of Pits and Fissures 384
Purpose of Sealant 384
Criteria for the Ideal Sealant 384
Rationale for Using Pit and Fissure Sealants 387
Procedure of Pit and Fissure Sealant Application 387
Indications for Use 388
Contraindications 388
Sealant Retention 388

Incipient Fissure Caries and Sealants 389
Preventive Resin Restorations 389
Fluoride Containing Sealants 390
Public Health Sealant Programs 390
Cost Effectiveness 390
Sealant Failure 391
Newer Sealants 391

34. Atraumatic Restorative Treatment 395
CM Marya

Principles 395
Reasons of Using Hand Instruments for ART 395
Material Used 395
Contraindications for ART 395
Instruments 395
Materials 396
Restoring One-surface Cavities Using ART 396
Treatment Material (Glass Ionomer as a Restorative Material) 397
Restoring Multiple-surface Cavities Using ART 398
Monitoring ART Restorations 399
Protocol for Failed or Defective Restoration 399
Advantages and Limitation of ART 399
Failure Prevention and Management 400

35. Prevention of Dental Caries 401
CM Marya

Caries Formation 401
Methods of Prevention of Dental Caries 402
Increase the Resistance of the Teeth 403
Combat Caries-inducing Microorganisms 403
Modify the Diet 403
Increase the Resistance of the Host/Teeth 404
Systemic Use of Fluoride 404
Topical Fluorides 405
Combat Caries-inducing Microorganisms/Plaque Removal and Control 406
Modify the Diet /Diet Control 407
Strategies for Prevention of Dental Caries 408
The Caries Balance 409
Modifying the Carious Process 410
Risk Groups for Dental Caries 410
Anticipatory Guidance: Parent and Patient Education 410
Levels of Prevention of Dental Caries 411
Behavior Modification in High Caries Risk Children 412
Preventive Therapy Based on Risk Factors 412
Behavior Modification in Geriatrics 412

36. Prevention of Periodontal Disease 415
CM Marya

Oral Hygiene Assessment 415
Stages of Periodontal Disease 415
Prevention of Periodontal Disease 416
Methods of Prevention of Periodontal Disease 417
Patients' Role in Preventive Periodontal Therapy 420
Supportive Periodontal Therapy (SPT) 420

37. Prevention of Malocclusion 422
CM Marya, Gurkeerat Singh

Introduction 422
Preventive Measures Undertaken (Preventive Orthodontics) 422
Parent Counseling 422
Caries Control 423
Space Maintenance 424
Exfoliation of Deciduous Teeth 424
Abnormal Frenal Attachments 424
Locked Permanent First Molars 424
Abnormal Oral Musculature 425
Space Maintenance (in the Deciduous and the Mixed Dentition) 425
Factors to be Considered for Space Maintenance 426
Ideal Requirements of Space Maintainers 427
Classification of Space Maintainers 427
Interceptive Orthodontics 427
Resolution of Crowding 431

38. Wasting Diseases of Teeth 434
CM Marya

Introduction 434
Tooth Wear 434
Attrition 434
Abrasion 434
Erosion 435
Abfraction 437
Epidemiology of Tooth Wear 437
Prevention of Tooth Wear 439

39. Prevention of Dental Trauma 441
CM Marya

Causes 441
Mechanism for the Action of the Mouthguards 442
Selection of a Mouthguard 442
Types of Mouthguard 443
Steps in Mouthguard Formation 444
Preventing Dental Injury in Childcare 445
Prevention of Dental Trauma 445
Primary Prevention 445
Playground Surfaces 446
Outdoor Home Playground Safety Checklist (CPSC) 446
Early Treatment of Large Overjets (Mixed Dentition) 447
Secondary Prevention 447
First Aid for an Avulsed Tooth 448
Dental Office Treatment for an Avulsed Tooth 448

40. Occupational Hazards in Dentistry 450
CM Marya

Prevalence 450
Definition 450

41. Infection Control in Dentistry 455
CM Marya

Infection Control 455

Transmission of Infection 456
Standard Precautions 456
Components of Infection Control 457
Treatment Room Features 465
Single-use Disposable Instruments 469
Handling of Biopsy Specimens 469
Use of Extracted Teeth in Dental Educational Settings 469
Biomedical Waste Management 469

SECTION 4: BEHAVIORAL SCIENCES

42. Sociology as Applied to Dental Public Health 473
Manik Razdan, CM Marya

Definition 473
Historical Role of Medicine 473
Evolution of Human Society 473
Variation in Disease Patterns with Changing Society 474
Changing Society and Patterns of Dental Diseases 474
The Socio-environmental Approach (Social Model) 475
Health and Social Factors 475
Social Classes and the Reaction of Each to Dental Care 476
Age Inequalities in Health 478
Gender Inequalities in Health 479
Ethnic Inequalities in Health 479
Cultural Pattern and Concepts Taboos as Related to Health 479
Taboos Related to Dentistry 480
Medical Anthropology 481
History of Medical Anthropology 481
Traditional Medical Systems 481
The Relation of Sociology to Anthropology 481

43. Child Psychology 483
Bhavna Gupta, Anil Gupta

Definitions 483
Importance of Learning Child Psychology 483
Theories of Child Psychology 483
Other Theory 487

44. Behavior Management in Community Dentistry 488
Sadanand K, Anil Gupta

Documentation/Categorizing Behavior 488
Variables Influencing Child Behavior 489
Clinic Setup 489
Behavior Management 490

SECTION 5: DENTAL PRACTICE

45. Dental Practice Management 497
CM Marya

Definition 497
Establishment of Dental Office 497

Selection of Place 497
Selection of Location 497
Selection of Building 498
Financial Assistance 498
Designing of Dental Office 498
Management of Dental Office 498
Personnel Management 498
Patient Management 499
Record Management 499
Accounting and Other Financial Aspects of Dental Practice 500
Factors Influencing Dental Practice 500
The Ways of Initiating a Dental Practice 500
Starting an Own Practice 500
Buying an Old Practice and/or Working with an Associate Dentist 500

46. Forensic Dentistry 501
CM Marya

Definition 501
Constituents of Forensic Odontology 501
History 501
Role of Teeth in Determination of Human Identity 502
Bite Marks 503
Mass Disaster 505
Age Estimation 505
Sex Identification 506
Internal and External Documentation and Communication Problems 506
Forensic Radiology 506
Child Abuse 507
Cheiloscopy 507
Forensic Anthropology 507
Computer Odontology 508

47. Computers in Dentistry 509
CM Marya

Parts of Computer 509
Applications of Computers in Dentistry 511

48. Ergonomics in Dentistry 517
CM Marya

Neck and Shoulder 517
Wrist and Hand 518
Lower Back Pain 518
Psychosocial Factors and Work-related MSDs in Dentistry 518
Prevention Strategies Work Place Intervention 518
Provide Sufficient Space 519
Accommodate Individual Preferences 519
Reduce Physical Effort 519
Instrument Design 519
Hand Instruments 519
Dental Handpieces 519
Lighting 520
Magnification 520
Operator Chair 520

Patient Chair 520
Posture/Positioning 520
Scheduling 521
Personal Protective Equipment 521

49. Consumer Protection Act 522
Avinash J, Swaroop Savanur

Introduction 522
Nature of the Legal System 522
Definitions 522
Consumer Disputes Redressal Agencies 523
Preventive Steps Against Litigation 525
Consent 526
Protection against Outcome of Litigation 528

50. Comprehensive Dental Care 529
Anil Ankola

Initial Care versus Maintenance Care 529
Prevention versus Treatment 529
Manpower Involved in Comprehensive Dental Care 529
Prerequisites for a Good Comprehensive Dental Care Program 530
Record Maintenance 530
Challenges and Limitations 530
Role of Public Health Dentists 530

Definitions 531

Index 541

Chapter 1

Changing Concepts of Health and Prevention of Disease

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Health is defined in the World Health Organization's Constitution as "a state of complete physical, social and mental well-being, and not merely the absence of disease or infirmity.

Thus health "is a positive concept emphasizing social and personal resources as well as physical capabilities".

To be healthy is to be in a state of homeostasis (balance) with one's surroundings. A healthy person, therefore, needs to maintain healthy habits such as taking regular exercise and adequate rest, adopting a high level of personal hygiene, eating a nutritionally balanced diet, abstaining from the abuse of drugs and alcohol, taking care of one's mental well-being and developing social skills to interact in a positive manner within society.

DETERMINANTS OF HEALTH

Many factors combine together to affect the health of individuals and communities. Whether people are healthy or not, is determined by their circumstances and environment. The factors which have been found to have the most significant influence – for better or worse – are widely known as the *determinants of health*. While health and social services make a contribution to health, most of the key determinants of health lie outside the direct influence of health and social care; for example, education, employment, housing, and environment. To a large extent, factors such as genetics, where we live, the state of our environment, our income and education level, and our relationships with friends and family all have considerable impacts on health, whereas the more commonly considered factors such as access and use of health care services often have less of an impact.

Public Health Agency of Canada and the *World Health Organization* has identified 12 determinants of health:

1. *Income and social status:* Health status improves at each step up the income and social hierarchy. High income determines living conditions such as safe housing and ability to buy sufficient good food. The healthiest populations are those in societies which are prosperous and have an equitable distribution of wealth.
2. *Employment:* Unemployment, underemployment and stressful work are associated with poorer health. People who have more control over their work circumstances and fewer stress related demands of the job are healthier and often live longer than those in more stressful or riskier work and activities
3. *Education:* Health status improves with level of education. Education increases opportunities for income and job security, and equips people with a sense of control over life circumstances-key factors that influence health. Low education levels are linked with poor health, more stress and lower self-confidence.
4. *Social environments:* The array of values and norms of a society, in varying ways, influence the health and well-being of individuals and populations. In addition, social stability, recognition of diversity, safety, good working relationships, and cohesive communities provide a supportive society that reduces or avoids many potential risks to good health. Studies have shown that low availability of emotional support and low social participation has a negative impact on health and well-being.
5. *Physical environments:* Physical factors in the natural environment (e.g., air, water quality) are key influences on health. Factors in the human-built environment such as housing, workplace safety and road design are also important influences.
6. *Healthy child development:* The effect of prenatal and early childhood experiences on subsequent health, well-being, coping skills and competence is very powerful. Children born in low-income families are more likely than those born to high-income families to have low birth weights, to eat less nutritious food, and to have more difficulty in school.
7. *Personal health practices and coping skills:* Balanced eating, keeping active, smoking, drinking, and how we deal with life's stresses and challenges, all affect health.
8. *Health services:* Access and use of services that prevent and treat disease influencing health.

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9. *Social support networks:* Support from families, friends and communities is associated with better health. The importance of effective responses to stress and having the support of family and friends provides a caring and supportive relationship that seems to act as a buffer against health problems.
10. *Biology and genetic endowment:* Inheritance plays a part in determining lifespan, healthiness and the likelihood of developing certain illnesses.
11. *Gender:* Men and women suffer from different types of diseases at different ages.
12. *Culture:* Culture can be defined as all the ways of life including *arts, beliefs* and *institutions* of a population that are passed down from generation to generation. Culture includes codes of *manners, dress, language, religion, rituals,* norms of behavior such as law and morality, and systems of belief as well as the art. Customs and traditions, and the beliefs of the family and community, all affect health.

DETERMINANTS OF HEALTH

Public Health Agency of Canada and the *World Health Organization* have identified 12 determinants of health:

- Income and social status
- Employment
- Education
- Social environments
- Physical environments
- Healthy child development
- Personal health practices and coping skills
- Health services
- Social support networks
- Biology and genetic endowment
- Gender
- Culture

Dimensions of Health

Health is complex and involves the interaction of various factors. In 1948, the World Health Organization identified parameters to measure the functionality of an individual. The first three identified barometers include the physical, the social, and the mental constructs. Later, the emotional, spiritual, and environmental dimensions were added to the list.

(i) Physical

It is an ability of human body structure to function properly. Levels of physical fitness are determined by interacting genetic, environmental and individual factors. It is also affected by many interacting variables such as age, sex, diet, disease, stress, sleep, physical activity, medical and dental services, and by one's life cycle and lifestyle.

A physically fit person can carry out usual daily activities without undue fatigue and has enough energy to enjoy leisure time and to meet common emergencies.

(ii) Social

It is the ability to interact with other individuals. Social deprivation - intellectual, emotional, ethical, and spiritual - and prolonged exposure to social pathology and poverty may seriously impede the actualization of the individual's constructive potentialities.

(iii) Mental

Ability to process information and act properly.

(iv) Emotional

Ability to cope, adjust, and adapt.

(v) Spiritual

It is the belief in some force or dynamic other than humans. Human health involves a struggle to achieve a meaningful relationship with the universe and life. To ignore humankind's psychospiritual nature in developing models of health, would be to deal with a dehumanized caricature.

(vi) Environmental

It comprises of (i) External: one's surroundings, (e.g., habitat, occupation) and (ii) Internal: an individual's internal structure (e.g., genetics)

THEORIES OF DISEASE CAUSATION

i. *Germ theory of disease (monocausal):* Work of Koch and Pasteur revealed that the prevailing health problems of the time were the products of living organisms. Isolation of bacillus causing tuberculosis and identification of the organism responsible for 22 infectious diseases between 1880 to 1900, gave rise to the idea that each disease had a single and a specific cause. A set of rules was formulated by Koch (Koch postulates) for establishing causal relationship between a microorganism and a disease states. In brief, it was essential that to be ascribed a causal role, the agent must always be found with the disease in question and not with any other disease.

ii. *Epidemiological triad:* The germ theory could not explain why not all those exposed to pathogen become ill: an organism or other noxious agent is a necessary, but not a sufficient cause of disease. The epidemiological triangle approach sees disease as the product of an interaction between an agent, a host, and the environment. The epidemiological triangle is useful in understanding infectious disorders, but is less useful with respect to chronic and degenerative disorders such as stroke arthritis and heart disease.

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iii. *Web of causation:* The web of causation considers all the predisposing factors of any type and their complex interrelationship with each other. This model is ideally suited for study of chronic diseases, where the disease agent is often not known. The disease is the outcome of the interaction of the multiple factors. It does not mean that to control a disease all or most of the factors need to be removed or controlled. The removal or elimination of even one factor may sometime be sufficient to control a disease provided that factor is sufficiently important.

iv. *The theory of general susceptibility:* This theory has emerged over the past 25 years and is different in important ways from monocausal and multicausal cause of disease. It is not concerned with identifying single or multiple risk factors associated with specific disorders. It seeks to understand why some social groups are more susceptible to disease and death in general.

v. *The socio-environmental approach:* During the 1980s, the theory of general susceptibility became more explicitly formulated as the socio-environm ental approach. This approach seeks to identify the factors which make and keep people healthy and is not much concerned with the cause of the disease. It focuses on the population rather than the individuals. It forms the basis for the health promotion strategies.

THEORIES OF DISEASE CAUSATION

Germ theory:
Disease is caused by transmissible agents.
A specific agent is responsible for one disease only (one-to-one relationship).

Epidemiological triad:
- Exposure to an agent does not necessarily lead to disease.
- Disease is the result of an interaction between agent, host and environment.
- Disease can be prevented by modifying the factors that influence the exposure and susceptibility.

Web of causation:
- Disease is a result of complex interaction of many risk factors.
- Any risk factor can be concerned in more than one disease.
- Disease can be prevented by modifying these risk factors.

General susceptibility:
- Some social groups have higher mortality and morbidity rates from all causes.
- It is an imperfectly understood general susceptibility to health problems.
- This is probably because of complex interaction of the environment, behavior and life-styles.

Socio-environmental approach:
- Health is strongly influenced by social and physical environment
- Risk conditions produced by such an environment affect health directly and through the physiological, behavioral and psychosocial risk factor that they create.
- Improving health requires modification of these environments.

Prevention of Disease

Definition

Prevention can be defined as 'the action of keeping from happening, or of rendering impossible, an anticipated event or act.'

This definition assumes that the thing being prevented is anticipated, but it does not mean that the extent, severity, or extent of the thing is always known. Prevention in health care means action to stop ill health before it begins.

Criteria for Disease Prevention

1. The disease and conditions are significant.
2. There is prevention that works.
3. Prevention is better than cure, repair, or doing nothing.
4. Sufficient resources are available to implement the preventive measures.
5. The economics can be calculated.
6. The process is ethical.

1. *Disease is significant:*
Significance of disease can be assessed in terms of three factors;
   - *Incidence and prevalence* (how much disease is there and how many people are affected).
   - *Mortality and morbidity* (what are the effects of disease – mild discomfort, disablement or death).
   - *Economics* (what is the cost of the disease to the individual or the nation).
2. *There is prevention that works:*
For an effective preventive strategy
   - The natural history of disease must be understood (etiology; determinants; predisposing, initiating, exciting, environmental factors; stages of disease progression etc.).
   - There should be an effective intervention available.
3. *Prevention is better than cure, repair, or doing nothing:*
Even if a preventive method is available, certain factors need to be considered:
   - Acceptability
   - Economics
   - Balance against process and outcome of disease.
   - Acceptable associated risk
4. *Availability of resources to implement the preventive measures:*
This includes all necessary and sufficient resources such as
   a. Manpower numbers.
   b. Manpower skills and ability
   c. Materials.
   d. Time.
   e. Political will.

   Often sufficient resources are available but priority for their utilization is not there.

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5. *Economics:*
   Economics can be calculated by:
   a. Cost efficiency
   b. Cost benefit
   c. Cost utility
   To overcome the difficulty of comparing different health care approaches such as *cost effective analysis* (CEA) and *cost benefit analysis* (CBA) an approach termed *cost utility analysis* (CUA) has been developed where a universal currency, a single quantitative unit is constructed.

   The terms could be understood in terms of dentistry, as follows:

- Cost Efficiency (Effectiveness) — Cost of implementation / No. of tooth surfaces saved
- Cost Effectiveness (Efficiency) — Cost of implementation / Savings in cost of treatment
- Cost Benefit (Utility) — Cost of implementation / Benefits to quality of life

6. *Ethics*
   Ethics is concerned with what is right or what is wrong. Ethics in health care including prevention is as valid in preventing strategies as in any other element of health care provision.

An Ideal Public Health Measure Should Be

1. Of proven efficacy in the reduction of the targeted diseases.
2. Easily and efficiently implemented, using minimum quantity of materials and equipments.
3. Medically safe.
4. Readily administered by non-medical person.
5. Attainable by the beneficiaries regardless of their socio-economic, income, educational and occupational status.
6. Readily available and easily accessible to large number of individuals.
7. Inexpensive and hence affordable to majority of population.
8. Uncomplicated and easily learned by people.
9. Administered with maximum acceptance on the part of the patients.
10. Administered with minimum compliance on the part of the people.

Successful prevention depends upon:

- A knowledge of causation,
- Dynamics of transmission,
- Identification of risk factors and risk groups,
- Availability of prophylactic or early detection and treatment measures,
- An organization for applying these measures to appropriate persons or groups, and
- Continuous evaluation of development of procedures applied

LEVELS OR CATEGORIES OF PREVENTION

These can be studied under two main frameworks:

A. Levels of Prevention

i. Primordial prevention
ii. Primary prevention
iii. Secondary prevention
iv. Tertiary prevention.

B. Approaches of Prevention

- High risk (target) strategy
- Mass (whole population) strategy.

LEVELS OF PREVENTION

i. *Primordial prevention:* It is the prevention of emergence or development of risk factors in countries or population group in which they have not yet appeared. Individual and mass education is main intervention method in primordial prevention.

ii. *Primary prevention:* It is defined as 'action taken prior to the onset of the disease, which removes the possibility that a disease will even occur'. It is carried out on healthy populations. Information and / or public health measure to the whole population may be sufficient to maintain a disease free environment. It may be accomplished by measures designed to promote general health and well being or by specific protective measures.

iii. *Secondary prevention:* It can be defined as 'actions which halts the progress of a disease at its incipient stage and prevents complications'. It is carried out on targeted population identified by their being exposed to, or indulgence, in factors that place them 'at risk'. The individual or the population is required to change, either to take some new action, or to cease an established action, or both, in order to lower the levels of risk.

iv. *Tertiary prevention:* It provides a cure at an early stage in disease process, containing the disease or its effects on a long term basis and seeks to prevent a recurrence of the disease. It can be defined as 'all measures available to reduce or limit impairments and disabilities, minimizing suffering caused by existing departures from good health and to promote the patients adjustment to irremediable conditions'. The individual or population is aware of the disease, can see its effects and requires rehabilitation.

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Modes of Intervention

Primary Prevention (Prepathogenesis)

Primary preventive services are those that prevent the initiation of disease.

a. *Health promotion:* It is process of enabling people to increase control over and to improve health. This can be achieved by
   i. Health education; instruction on proper plaque removal, daily tooth brushing and flossing
   ii. Environment modification such as safe water, control of insects and rodents.
   iii. Nutritional interventions: improvement of nutrition in vulnerable group.
   iv. Lifestyle and behavioural changes; which favor health
b. *Specific protection:* These are activities designed to protect against disease agents by decreasing the susceptibility of the host or by establishing barrier against agents in the environment. Methods include immunization, use of specific nutrition, avoidance of allergens, protection from carcinogens, ingestion of optimally fluoridated water and application of pit and fissure sealants.

Secondary Prevention

(Pathogenesis: Initial Stage of Pathogenesis)

It is defined as "action which halts the progress of a disease at its incipient stage and prevents complications."
These services intervene or prevent the progression and recurrence of disease.

a. *Early diagnosis:* WHO Expert Committee in 1973 defined early detection of health disorders as "the detection of disturbances of homeostatic and compensatory mechanism while biochemical, morphological and functional changes are still reversible."

   The earlier the disease is diagnosed and treated the better is its prognosis and helps to prevent the occurrence of more cases.

   Actions that detect and treat disease at an early stage thus hinder the progress of a disease and prevent complications. i.e. intervention in early pathogenesis phase.

   The methods (tools) employed for early diagnosis are:

1. Screening for sub-clinical disease, either in screening surveys or in periodic medical examinations.
2. Case finding (individual and community).

b. *Prompt treatment:* Secondary prevention attempts to arrest the disease process, restore health by seeking out unrecognized disease and treating it before irreversible pathological changes take place, and reverse communicability of infectious diseases.

Tertiary Prevention

(Pathogenesis: Late Stage of Pathogenesis)

Actions taken when the disease process has advanced beyond its early stages i.e. intervention in late pathogenesis phase.

It is defined as "all the measures available to reduce or limit impairments and disabilities, and to promote the patients' adjustment to irremediable conditions."

Intervention that should be accomplished in the stage of tertiary prevention is *disability limitation,* and *rehabilitation*.

The aim of tertiary prevention is to limit disability and prevent further complications or death.

a. *Disability limitation*

   The objective of this intervention is to prevent or stop the transition of the disease process from impairment to handicap (Fig. 1.1). The sequence is as follows:

   - Disease
   - Impairment
   - Disability
   - Handicap

   i. *Impairment*: It is "any loss or abnormality of psychological, physiological or anatomical structure or function."
   ii. *Disability*: It is "any restriction or lack of ability to perform an activity in the manner or within the range considered normal for the human being."

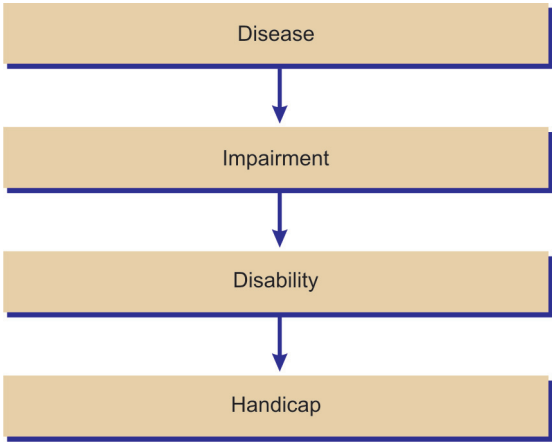

Fig. 1.1: Transition of disease process

Levels of prevention	*Primary*	*Secondary*	*Tertiary*
Concept of prevention	Prevention of disease initiation	Prevention of disease progression and recurrence	Prevention of loss of function
Modes of intervention	Health promotion specific protection	Early diagnosis and prompt treatment	Disability limitation rehabilitation

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iii. *Handicap*: It is termed as "a disadvantage for a given individual, resulting from an impairment or disability that limits or prevents the fulfillment of a role in the community that is normal (depending on age, sex, and social and cultural factors) for that individual."

Tools for tertiary prevention include rehabilitation

b. *Rehabilitation:* It is defined as "the combined and coordinated use of medical, social, educational, and vocational measures for training and retraining the individual to the highest possible level of functional ability."

It is a measure to train the disable individuals to reach the highest level of functional ability by using combined coordinated medical, social, vocational, psychological and educational measures.

Rehabilitation comprises:

1. Medical rehabilitation: restoration of function or physical loss.
2. Educational rehabilitation: change of educational methods.
3. Vocational (occupational) rehabilitation: restoration of the capacity to earn a livelihood.
4. Social rehabilitation: restoration of family and social relationships.
5. Psychological rehabilitation: restoration of personal confidence

Examples of rehabilitation:

1. Special schools for blind pupils.
2. Provision of aids for crippled.
3. Reconstructive surgery for leprotics.
4. Modification of life for tuberculous or cardiac patients.

APPROACHES OF PREVENTION

High-risk Strategy

Here the population is classified in relation to the degree of risk which individuals or groups of individuals exhibit, or are exposed to. It aims to bring preventive care to individuals or a group at special risk, which will reduce their risk factors.

Advantages

a. Doctor-patient relationship.
b. Better motivation.
c. Cost benefits.
d. Individual appropriateness.

Disadvantages

a. Criteria for 'at risk' not clear.
b. Cost of screening.
c. Does not tackle cause of disease.
d. Misses transitional populations.

Mass Strategy

"Population strategy" is directed at the whole population irrespective of individual risk levels.

This approach does not differentiate between individuals in any defined population and is directed towards the whole population. It treats all individuals as at equal risk. Underlying factors which contribute to the etiology of the disease, or themselves are causative factors, are targeted for alteration. The population approach is directed towards socio-economic, behavioral and lifestyle changes.

Advantages

a. Easier.
b. Behaviorally appropriate for whole population.
c. Gets to the cause of the disease.
d. Reaches all who may become high risk / sufferers.

Disadvantages

a. Requires a lot of motivation.
b. Dilution of efforts.
c. Dilution of effects.
d. Less specific.
e. Higher rate of failure.
f. Lessened benefit to individuals.

Barriers (Challenges) to Preventive Strategies

1. *Diversity of population*
   A homogeneous message may not be appropriate for a heterogeneous population. Population varies in social status, age, ethnicity, differing attitudes, beliefs, expectations, knowledge, understanding and disease level etc.
2. *Inherent beliefs/mores*
   These include – fear of health/medical profession, confusion from previous message, erroneous message etc.
3. *Advertising*
   Propaganda produces pressure selling on children and blackmail on parents.
4. *Pressure groups*
   Many pressure groups base their opposition to health promoting moves on the basis of loss of autonomy and choice (seat belts, smoking in public places), and others on medical and epidemiological evidence (water fluoridation etc.).
5. *Access*
   Access to people to improve health is usually poorest to those who are in most need of intervention, e.g. Social class III, IV, V, kids, risk group.
6. *Resources*
   Although governments stress the importance of prevention, the major drain on health resources is the acute health care sector. Directing resources into prevention is still not completely addressed.

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Chapter 2

Basic Epidemiology

Abdul Rashid Khan, KA Narayan

INTRODUCTION TO EPIDEMIOLOGY

Health and disease can be studied in 3 basic ways, (i) observation of effects on individuals (ii) laboratory experiments (iii) measuring their distribution in population (epidemiology).

The origin of the word epidemiology is from the Greek word 'epi' meaning upon, 'demos' meaning people and logos meaning 'doctrine'; the literal translation would be 'the doctrine of what is upon the people'.

The international epidemiological association defines epidemiology as "the study of the *distribution* and *determinants of* health related states and events in the populations and the application of this study to control of health problems". The primary unit of concern is groups of person not individuals.

Scope of Epidemiology

Epidemiology covers all major health problems in the community including:

- Communicable diseases
- Chronic degenerative, metabolic, neoplastic diseases
- Nutritional deficiencies
- Occupational health and injuries
- Mental and behavioral disorders
- Population issues and demographic trends.

Uses of Epidemiology

- The most important use of epidemiology is to increase the understanding of disease, shared with the other medical sciences, but looking at communities or populations
- Determine the cause of disease so that previously unavailable preventive or control measures may be successfully applied
- Epidemiology clarifies causative agents, the factors in web of causation, the populations at highest risk and environmental and other determinants
- Epidemiology is concerned with describing the natural history of disease, including not only the clinical stages seen in hospitals and medical practice but unapparent, sub clinical and carrier states and precursor states of chronic diseases
- Epidemiology is used to monitor the health of populations (surveillance) to chart changes over time, place and person and to determine which diseases are of most public health importance. By analyzing trends it is able to predict and devise methods of control
- The design, conduct and interpretation of field trials, vaccinations and control programs, therapeutic measures such as environmental modifications and dietary changes, concerned with populations not individuals
- It supplies information necessary for health planning and development and management of programs for disease prevention and control
- It supplies tools for evaluating health programs
- It provides a foundation for public policy and for making regulatory decisions relating to environmental problems.

Epidemiological Perspective

Epidemiology is about information, the information needed for health planning, supervision and evaluation of the health promotion and disease control activities. The key components of the data needed can be approached through a series of questions.

- Who? – Who is affected? - referring to age, sex, social class, ethnic group, occupation, heredity and personal habits. (These are person factors)
- Where? – Where did it happen? - in relation to place of residence, geographical distribution and place of exposure. (Place factors)
- When? – When did it happen? - in terms of months, season or year. (Time factors)
- What? – What is the disease or condition? - its clinical manifestation and diagnosis.
- How? – How did the disease occur? - in relation to the interplay of the specific agent, vector, source of infection, susceptible groups and other contributing factors.
- Why? – Why did it occur? - in terms of the reasons for the disease outbreak.

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- What now? – The most important question - What action is now to be taken as a result of the information gained?

Epidemiological Concept

The concept which is sometimes called the ecological concept of disease or the concept of multiple causations is based on the three premises:

1. Disease results from an imbalance between the disease agent and the host.
2. The nature and the extent of the imbalance depends upon the nature and characteristics of the agent and the host.
3. The characteristics of the agent and the host and their interactions are directly related to and largely dependent on the nature of the physical, biological and social environment.

The epidemiological concept of disease holds that health and disease in an individual or community are outcomes of the dynamic relationship between the agent, the host and the environment (Fig. 2.1). A state of equilibrium between these factors indicates no disease; any disturbances of this equilibrium brought about by changes in the inherent characteristics of the agent the host and the environment results in disease.

Agents

The agent has been defined as an element, a substance or a force either animate or inanimate, the presence or the absence of which may, following effective contact with the susceptible human host and under proper environmental conditions, serve as a stimulus to initiate or perpetuate a disease process. The classifications of agents are:

- Biological agents – due to living agents. Viruses, bacteria, fungi, protozoa
- Nutritional factors – both excess and deficiencies such as calories, proteins, vitamins
- Chemical agents – e.g. lead, solvents
- Physical agents – humidity, vibration, heat, light, cold, radiation, etc
- Mechanical agents – explosives, bullets, knives, etc
- Social and psychological stressors – poverty, smoking, drug abuse, work stress, etc.

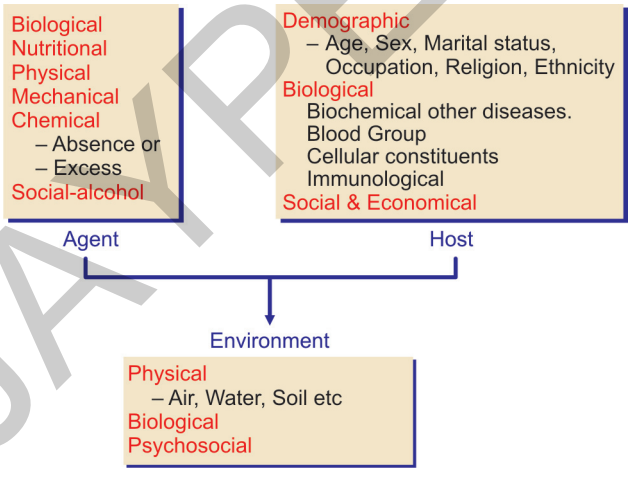

Fig. 2.1: Epidemiological triad and their interaction

Human Host

The factors which influence the exposure of response include:

- Age
- Sex
- Family size
- Marital status
- Religion
- Occupation
- Intercurrent disease
- Ethnic or racial factors
- Habits and customs
- Inherent immunity or non specific immunity
- Immunity – passive immunity, active immunity.

Environment

The environment is the sum total of all external conditions and influences that affect the life and development of an organism. It thus influences both the agent and the host.

- Biological environment – infectious agents of disease, reservoirs of infection, vectors that transmit disease, plants and animals.
- Social environment – the overall economic and political organization of a society and of the institutions by which individuals are integrated into the society at various stages in their lives.
- Physical environment – heat, light, air, water, radiation, gravity, chemical agents.

Risk Factors: The "Beings" Model

Epidemiological research has focused on life threatening diseases such as cancer. Majority of cancers were potentially preventable and were due to "extrinsic factors". However extrinsic or environmental factors have often been misinterpreted to mean "man made chemical" Hence the BEINGS is a helpful acronym to remember the major categories of risk factors.

Biological factors and behavioral factors: Gender, age, weight, smoking behavior, etc.

Environmental factors: Rainfall, season, housing, air-conditioning, etc.

Immunological factors: Immunity and Immunodeficiency.

Nutritional factors: Cholesterol in heart diseases

Genetic factors: Thalassemia, Hemophilia, etc.

Services, social factors and spiritual factors.

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MEASURING HEALTH

There is a need for accurate information on illness (morbidity) and death (mortality) because of the high economic loss, social disturbances as well as the cost of medical care associated with them and to enable comparison within and between societies at a given point in time or over different time periods. Health is measured by morbidity and mortality statistics.

Numerator and Denominator

Epidemiology is concerned with either the presence of health problems in a population or the occurrence of new health events in a population. In both the cases an epidemiological measure (or expression) has at least two components: a numerator and a denominator.

The numerator in a disease ratio or rate for example is either existing (prevalent) cases as with measures of prevalence or new (incidence) cases as with incidence.

The denominator is the population at risk or the population in which cases exist or have occurred.

Ratio, Proportion and Rate

There are three basic classes of mathematical quantity used to measure health status and the occurrence of health events on populations.

- *Ratio* – is the general term that includes a number of more specific measures, such as proportion, percentage and rate. A ratio is obtained by dividing one quantity by another without implying any specific relationship between the numerator and the denominator. The value of a ratio can range from minus to plus infinity
- *Proportion* – is a type of ratio in which those who are included in the numerator must also be included in the denominator i.e. the numerator is a subset of the denominator. The magnitude of proportions is usually expressed as a percentage
- *Rate* – is a ratio in which there is a distinct relationship between the numerator and the denominator. A specified time period is an essential component of the denominator

Rates are used as a comparison of an observed rate with a target rate, a comparison of two different populations at the same time (the two population should be similar and are measured in exactly the same way), a comparison of the same population at two different time periods (used for studying time trends).

Categories of Rates

i. *Crude rates:* rates that apply to entire populations, without a reference to any characteristics of the individuals in it. They are valid rates but often misleading.

ii. *Specific rates:* rates that are used when a population is divided into more homogenous subgroups based on a particular characteristic of interest e.g., age.

iii. *Standard rates:* rates that are standardized to compare between two or more different populations.

Measures of Disease Frequency

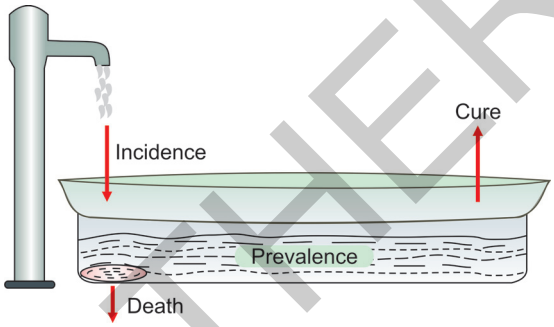

Fig. 2.2: Relationship between incidence and prevalence

Prevalence

Prevalence is an estimate of the proportion of individuals in the population with a given disease, disability or health state at a particular point in time. Prevalence is the measure of the existence of a particular condition i.e. prevalence measures the probability of people having a disease at a given point in time.

Prevalence is not strictly a rate although it is sometimes referred to as one. Prevalence is a proportion and should usually be reported as one. The major difference between incidence and prevalence is that knowledge of time of onset is not required in a prevalence study. Denominators in prevalence always include the entire population since the numerator contains old as well as new cases.

Prevalence depends on two factors (Fig. 2.2): the number of people who have been ill in the past (previous incidence) and the duration of their illness. P~ I × D, if incidence and duration have been stable over a long period of time then this formula becomes P = I × D (Table 2.1).

Table 2.1: Prevalence of disease over a period of time

Increased by	*Decreased by*
Longer duration of the disease	Shorter duration of the disease
Prolongation of life of patients without cure	High case fatality rate from disease
Increase in incidence	Decrease in incidence
In migration of susceptible people	Out migration of cases
Better reporting	Improved cure rate of cases

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There are two types of prevalence rates point prevalence and period prevalence.

Point Prevalence:

Attempts to measure disease at one point in time,

$$\text{Prevalence} = \frac{\text{Number of existing cases of a disease at a point of time}}{\text{Total population at that point of time}} \times 1000$$

Point prevalence is preferred over period prevalence since it is more precise.

Period Prevalence:

It describes the prevalence of disease over a period of time.

$$\text{Period prevalence} = \frac{\text{Number of existing cases of a disease during a period or interval}}{\text{Average population during a period or interval (usually at mid point)}} \times 1000$$

Incidence

Incidence measures the number of new cases or new events of disease which develop on a given population during a specified time period. Incidence rates measure the probability that healthy people will develop a disease during a specified period of time. To determine incidence, it is necessary to follow prospectively a defined group of people and determine the rate at which new cases of disease appear.

Incidence may Change with the Following Factors

- Introduction of a new risk factor
- Changing habits
- Changing virulence of causative organism
- Changing potency of treatment of intervention programs
- Selective migration of susceptible persons to an endemic area, which increases the incidence of the disease.

Cumulative Incidence

CI is the proportion of people in a total population at risk and free of disease at the start of a particular time period who become diseased or develop the incident condition during the specified time period. CI provides an estimate of the probability (or risk) that an individual will become diseased in the specified time period

$$\text{CI} = \frac{\text{Number of new cases of a disease in a given period of time}}{\text{Total population at risk (Free from disease at beginning of period)}} \times 1000$$

Incidence Rate (Incidence Density)

Often every individual in the denominator is not followed for the specified period of time. For a variety of reasons including loss to follow-up, death or migration different individuals will be observed for different lengths of time. For differing periods of observation, person time denominator must be used.

IR is a true rate and is considered to be an instantaneous rate of development of disease in a population. The numerator is the number of new cases or incident cases in the population.

$$\text{Incidence rate} = \frac{\text{Number of new cases}}{\text{Person time of observation}} \times 1000$$

Mortality Statistics

Although mortality is far from being an ideal measure of the health of a population, thanks to vital registration systems, it is often the most easily available and accessible indicator that can be used by health agencies in the planning, implementation and evaluation of health services. Morbidity is of course a better indicator of health since it covers the whole spectrum of disease but there are numerous problems and errors associated with it. As most countries have a "vital events" registration system calculating mortality rates is easy. However, if deaths are not reported the rates will be artificially low.

The commonly used rates are crude death rate, standardized death rate, cause – specific death rate, age-specific death rate, case fatality rate, proportionate mortality rate, infant mortality rate (IMR), Neonatal mortality rate (NMR), postneonatal mortality rate (PNMR), prenatal mortality rate and maternal mortality rate (MMR).

Calculations for Common Mortality Rates

$$\text{Crude death rate} = \frac{\text{Number of deaths among residents in an area in a calendar year}}{\text{Average population in the area in that year}} \times 100$$

$$\text{Cause-specific death rate} = \frac{\text{Number of deaths from a stated cause in a year}}{\text{Average (mid-year) population}} \times 1000$$

$$\text{Age-specific death rate} = \frac{\text{Number of deaths among persons of a given age group in a year}}{\text{Average (mid-year) population in the specified age group}} \times 1000$$

$$\text{Case fatality rate} = \frac{\text{Number of deaths from a disease}}{\text{Number of clinical cases of that disease}} \times 100$$

$$\text{Neonatal mortality rate (NMR)} = \frac{\text{Deaths in a year of children <28 days of age}}{\text{Number of five births in same year}} \times 1000$$

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$$\text{Postneonatal mortality rate (PNMR)} = \frac{\text{Deaths in a year of children = 28 days of age upto 1 year}}{\text{Number of live births in the same year}} \times 1000$$

$$\text{Prenatal MR} = \frac{\text{Births (28 wks or more of gestation) + deaths in the first week of life}}{\text{Stillbirths + Number of live births in same year}} \times 1000$$

$$\text{Toddler MR} = \frac{\text{Deaths of children aged 1 to 4 years in a given year}}{\text{Mid year population of children aged 1 to 4 years for the same year}} \times 1000$$

$$\text{IMR} = \frac{\text{Number of deaths in a year of children less than 1 year of age}}{\text{Number of live births in same year}} \times 1000$$

$$\text{MMR} = \frac{\text{Number of deaths from pregnancy related causes in a year}}{\text{Number of live births in same year}} \times 100{,}000$$

EPIDEMIOLOGICAL STUDIES

Epidemiological studies are required to measure the rates of disease occurrence and the associated factors in a population, to make an unbiased comparison of those with or without a disease or risk factor and to make interventions. This is achieved by a good research design. Some research questions can be answered by more than one type of research design. The choice of design will depend on factors such as cost, speed and availability of data. Each design has advantages and disadvantages.

Design of Epidemiological Studies

The design of an epidemiological study serves the function of a measuring instrument. Though the design information is obtained from the population being studied, the researcher designs the study in such a way that valid estimates are obtained. A number of design options exist, each with their own purposes strengths and weaknesses.

The selection of the type of study is the core of a research design and is probably the single most important decision the investigator has to make. The strategy must include definition of variables, their levels and their relationships to one another.

The type of study design chosen depends on:

- The type of problem
- The knowledge already available about the problem and
- The resources available for the study.

Epidemiological studies are broadly classified as follows (Fig. 2.3):

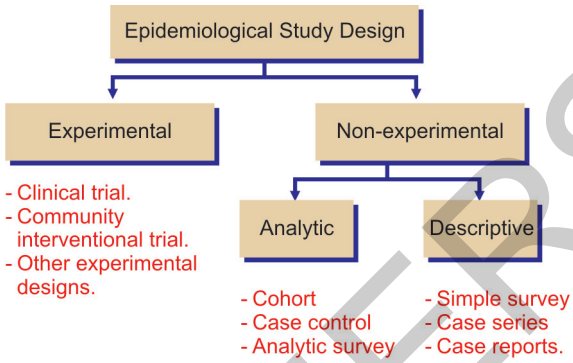

Fig. 2.3: Classification of epidemiological studies

Non-experimental (Observational)

In non-experimental studies, the assignment of subjects to exposure groups is not determined by the researcher, but rather by the study subjects themselves or by other factors. The possibility of bias in non-experimental studies is of constant concern.

There are two types of non-experimental designs.

- Analytical studies
- Descriptive studies.

Descriptive Studies (Who? What? Where? When?)

These studies involve the systematic collection, analysis and interpretation of data to give a clear picture of a particular situation. The wealth of data obtained in most descriptive studies allows the generation of hypothesis, which can then be tested by analytical experimental design. Both qualitative and quantitative techniques may be used.

In descriptive epidemiology we organize and summarize data according to *time, place and person*. These three characteristics are sometimes called the *epidemiologic variables.* This information provides important clues to the causes of the disease, and these clues can be turned into testable hypotheses.

Characteristics of Persons

- Age – overall the most important epidemiologic variable relating to exposure, susceptibility and pathogenesis. Age specific rates to make comparisons between populations must be determined. The population pyramid of the group studied must be considered
- Sex – anatomical, physiologic, psychological and behavioral characteristics account for many sex specific disease associations
- Ethnicity – genetic, physiologic, behavioral, environmental and socioeconomic characteristics of importance as determinants of disease
- Place of origin – genetic pool, environmental, cultural and behavioral and dietary factors

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- Marital status – a selective process, and associated with differences in physical state, behavioral and socioeconomic determinants of health
- Occupation – reflects physical, mental, psychological, environmental and socioeconomic characteristics related to disease patterns
- Socioeconomic – determines many of the above characteristics.

Characteristics of Place (Geographic, Landscape Epidemiology)

- Biologic environment – climatic and ecologic characteristics that determine flora and fauna, including human factors
- Chemical and physical environment – quality of air, water and food
- Social environment – cultural, behavioral patterns that determine risks, perceptions and responses.

Characteristics of Time

- Endemics – diseases which are regularly and continuously present
- Epidemic – a significant excess over that expected on basis of past experience; an unusual clustering over time
- Short time variation – point epidemics
- Periodic variations – seasonal changes, cyclical variations, secular variations
- Dynamics of disease – refers to distribution in time, is concerned with trends, cyclic and secular changes, intervals between exposures, degrees of exposure, incubation periods, communicability periods.

Types of Descriptive Studies

1. *Case studies* – this kind of study is based on reports of a series of cases of a specific condition or a series of treated cases, with no specifically allocated control group. They represent the numerator of disease occurrence and should not be used to estimate risks.
2. *Community diagnosis or needs assessment* – entails collection of data on existing health problems, programs, achievements, constraints etc. Their purpose is to identify existing needs and to provide base line data for the design of further studies or action.
3. *Epidemiological description of disease occurrence* – entails the collection of data on the occurrence and distribution of disease in population according to specific characteristics of individuals, place, and time.
4. *Ecological descriptive studies* – when the unit of observation is an aggregate (e.g. a family, clan or school) or an ecological unit (a village, town or district), the study becomes a descriptive ecological study.
5. *Descriptive cross sectional studies or community (population) surveys* – entails the collection of data on a cross section of the population, which may comprise the whole population or a proportion (a sample). They provide a prevalence rate at a point in time (point prevalence) or over a period of time (period prevalence). The study population at risk is the denominator of these prevalence rates. Included in these studies are surveys in which the distribution of a disease, disability, pathological condition, immunological condition, nutritional status are studied.

   This design may also be used in health systems research to describe prevalence by certain characteristics – the pattern of health service utilization and compliance – or in opinion polls.
6. *Longitudinal studies* – use ongoing surveillance or frequent cross sectional studies to measure trends of disease over a period of time in a given population. By comparing these trends in disease rates with other changes in the society the impact of these changes on disease occurrence can be assessed. E.g: effect of introduction of vaccines, natural and manmade disasters economic change.

All the above studies can be the source of hypothesis generation. Both cross sectional and ecological studies can be used in hypothesis testing (i.e. are analytical.)

Analytical Studies (How? Why?)

Analytical strategies are observational means used in epidemiological investigations to test specific hypotheses. The term 'analytical' implies that the study is designed to establish the cause of a disease by looking for association between exposure to a risk factor and disease occurrence.

The basic approach in analytical studies is to develop a specific testable hypothesis and to design the study to control for extraneous variables that could potentially confound the observed relationship between the studied factors and the disease. The approach varies according the specific strategy used (Fig. 2.4).

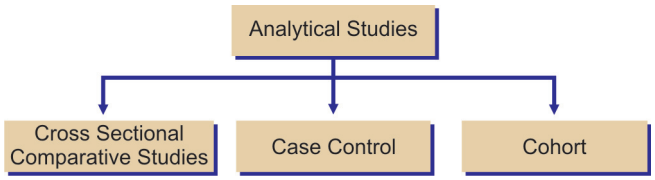

Fig. 2.4: Classification of analytical studies

Experimental (Interventional)

An experiment or an interventional trial is designed to evaluate the effect of an intervention in which the assignment of subjects to exposed and non exposed groups is designed by the researcher.

The researcher manipulates objects or situations and measures the outcome of his manipulations. Usually (but not always) two groups are compared, one in which the intervention takes place and another group that remains untouched.

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