Chapter 4
Broader Considerations of Medical and Dental Data Integration

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4.1 Economics of Clinical Data Integration

4.1.1 A Cost Benefit Analysis of Expanding Dental Insurance Coverage

Stephen Foreman

4.1.1.1 Introduction

Dental health insurance coverage in the United States is either nonexistent (Medicare and the uninsured), spotty (Medicaid) and limited (most employer-based private benefit plans). Perhaps as a result, dental health in the United States is not good. What public policy makers may not appreciate is that this may well be impacting medical care costs in a way that improved dental benefits would produce a substantial return to investment in expanded dental insurance coverage.

On the surface, it would appear to be politically and economically difficult or impossible to expand dental insurance coverage at this time. Health insurance costs have been rising at double digit rates. Most employers have been dropping health care coverage rather than expanding it (Kaiser Family Foundation 2010). Medicare trust funds are bankrupt (Social Security and Medicare Boards of Trustees 2011). Adding coverage would exacerbate an already alarming problem. Medicaid funding is a major source of state government deficits. Many states are slashing Medicaid coverage during this time of crisis (Wolf 2010). Improving Medicaid dental coverage during times of budget crisis would meet substantial political resistance.

Strikingly, strong and increasing evidence suggests relationships between oral health and a range of chronic illnesses. For example, recent findings show relationships between periodontal inflammatory conditions and diabetes, myocardial infarction, coronary artery disease, stroke, preeclampsia and rheumatoid arthritis. This suggests that improved oral health may well have the potential to reduce the incidence of chronic diseases as well as their complications. If chronic disease incidence is reduced it may be possible to avoid medical care costs related to treating them. It would be important to know more about the extent to which improved oral health could reduce health care costs and improve lives.

There are few, if any, studies of the costs of providing Medicare dental benefits, the costs of improving the Medicaid dental benefit or the cost of providing dental insurance to the uninsured. There are a few studies that indicate that periodontitis increases medical care costs, perhaps by as much as 20% (Ide et al. 2007; Albert et al. 2006).[1] Ideally there should be a controlled study to assess the benefit of providing dental coverage through a government payer system. For a preliminary inquiry we can consider work already done and using some cost and benefit estimates, determine whether it is possible that benefits of extending dental coverage may outweigh costs.

4.1.1.2 Dental Insurance and Coverage in the United States

The failure of Medicare to cover dental care has engendered some (albeit not much) public debate. In 2003, Congress enacted the Medicare Prescription Drug, Improvement, and Modernization Act (Medicare Part D). By 2009 Medicare provided $56.6 billion in benefit payments for outpatient prescription drugs and Medicaid paid 15.7 billion for outpatient prescription drugs (Center for Medicare and Medicaid Services 2010). Beneficiaries provided billions more in the form of monthly Part D premiums. The expense of the Medicare prescription drug program and the controversy surrounding its enactment may well have eroded public support for increased Medicare coverage. So while there has been no shortage of effort paid to improving Medicare, the one common theme in all of the recent initiatives is that dental care has been conspicuously

[1]A new study by Hedlund, Jeffcoat, Genco and Tanna funded by CIGNA of patients with Type II diabetes and periodontal disease found that medical costs of patients who received maintenance therapy were $2483.51 per year lower than patients who did not. CIGNA, Research from CIGNA Supports Potential Association between Treated Gum Disease and Reduced Medical Costs for People with Diabetes, http://newsroom.cigna.com/NewsReleases/research-from-cigna-supports-potential-association-between-treated-gum-disease-and-reduced-medical-costs-for-people-with-diabetes.htm, March 29, 2011, accessed June 23, 2011; Jeffcoat M (2011). Personal communication, 20 June 2011.

omitted. As a result, 43 million Medicare recipients in 2009 (US Census Bureau 2011) continue to have no dental insurance coverage through Medicare.[2]

Medicaid dental coverage is an optional benefit that states may or may not elect to provide. In Medicaid, both the State and the Federal government provide funds to cover healthcare services to eligible patients. The bulk of the money comes from the Federal government. Because the Medicaid dollars are limited and coverage for systemic diseases has precedence, Medicaid coverage of dental care has been spotty. Even where it has been provided, payments to dental providers have been so low as to make it difficult or impossible for Medicaid beneficiaries to obtain adequate dental care (Broadwater 2009). The 2008 recession increased the number of Medicaid eligible individuals nationwide. Further, the federal budget deficits of the past few years have reduced the federal contribution to state Medicaid programs. The combination of increases in the number of beneficiaries and diminished revenues has caused a number of states to eliminate or curtail Medicaid dental coverage (eHow 2011; Mullins et al. 2004). The result, 49 million Medicaid beneficiaries in the US (US Census Bureau 2011) in 2009 either had no dental insurance coverage or inadequate coverage.

Approximately 52 million people in the United States do not have health insurance (Kaiser Family Foundation 2010). Presumably, they have no dental insurance either. Further, not every employer provides dental insurance. A 1995 CDC survey found that 44.3% of adults do not have dental insurance coverage (Centers for Disease Control 1997). A 2006 Montana survey found that 53% of employers who offer health insurance do not offer dental insurance coverage (Montana Business Journal 2006). In 2009 there were approximately 202 million people enrolled in health insurance plans (US Census Bureau 2011). If half (a rough combination of the CDC and Montana percentages) of them do not have dental insurance it is likely that an additional 101 million (nonelderly, non-poor) people in the US do not have dental insurance coverage.

Finally, the term “dental insurance” is actually a misnomer.[3] Dental policies cover routine treatments, offer discounts for more complex treatment and impose a low yearly on total payments. In fact, it has been called “part insurance, part prepayment and part large volume discount” (Manski 2001). Effectively, many (if not most) people who have dental insurance find it coverage to be quite restrictive. For example, many impose a small yearly cap ($1,500 is common) or large coinsurance amounts (50% for orthodontia, for example) (Rubenstein 2005). Even with discounts it is easy for many people to exceed the annual limit.

Given the lack of dental insurance coverage it is not surprising that the status of oral health in the US is not particularly good. In 2002 approximately 26.5% of adults between the ages of 35 and 44 had untreated caries, 42% had decayed, missing and filled tooth surfaces and more than one-half of adults had gingival bleeding (Dental, Oral and Craniofacial Data Resource Center of the National Institute of Dental and Craniofacial Research 2002). Three fourths of adults in the US have gingivitis and 35% have periodontitis (Mealey and Rose 2008). If these levels of untreated disease were applied to most systemic diseases, there would be public outcry.

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[2]Some of them may have dental insurance coverage through their retirement health insurance.

[3]Perhaps it might more accurately be called a dental plan.

4.1.1.3 The Relationship Between Dental Problems and Chronic Illness

Over the past decade evidence has been building that there is a relationship between dental disease, particularly periodontal disease, and chronic illnesses. Mealey and Rose note that there is strong evidence that "diabetes is a risk factor for gingivitis and periodontitis and that the level of glycemic control appears to be an important determinant in this relationship" (Mealey and Rose 2008). Moreover, diabetics have a six times greater risk for worsening of glycemic control over time compared to those without periodontitis and, periodontitis is associated with an increased risk for diabetic complications. For example, in one study more than 80% of diabetics with periodontitis experienced one or more major cardiovascular, cerebrovascular or peripheral vascular events compared to 21% of the diabetic subjects without periodontitis (Thorstensson et al. 1996). Also, a longitudinal study of 600 type 2 diabetics found that the death rate from ischemic heart disease was 2.3 times higher in subjects with severe periodontitis and the death rate from diabetic nephropathy was 8.5 times higher (Saremi et al. 2005). Clinical trials have demonstrated that treatment of periodontal disease improved glycemic control in diabetics (Miller et al. 1992). Moreover, investigations have found an association between periodontal disease and the development of glucose intolerance in non-diabetics (Saito et al. 2004). While it is difficult to establish causality and it is possible that other factors influence periodontal disease and medical complications, these studies suggest that treatment of periodontitis substantially improves health and greatly reduces medical complications related to diabetes.

Similarly, periodontitis is associated with cardiovascular disease and its complications including ischemia, atherosclerosis, myocardial infarction and stroke. A study by Slade and colleagues found both a relationship between periodontitis and elevated serum C- reactive protein levels (systemic marker of inflammation and documented risk factor for cardiovascular disease) as well as a relationship among body mass index, periodontitis and CRP concentrations (Slade et al. 2003). Hung and colleagues evaluated the association between baseline number of teeth and incident tooth loss and peripheral arterial disease. They determined that incident tooth loss was significantly associated with PAD, particularly among men with periodontal disease potentially implying an oral infection-inflammation pathway (Hund et al. 2003). The same group of researchers used the population enrolled in the Health Professionals' Follow-Up Study (41,000 men free of cardiovascular disease and diabetes at baseline) to assess the relationship between tooth loss and periodontal disease and ischemic stroke. Controlling for a wide range of factors including smoking, obesity, and dietary factors, the researchers found a "modest" Association between baseline periodontal disease history and ischemic stroke (Joshipura et al. 2003). As early as 1993 DeStefano and colleagues found that among 9760 subjects, those with periodontitis had a 25% increased risk of coronary heart disease relative to those without. The association was particularly high among young men. The authors questioned whether the association was causal or not, suggesting that it might be a more general indicator of personal hygiene and possibly health care practices (DeStefano et al. 1993). In 2000 Wu and colleagues used data from the First National Health and Nutrition Examination Survey and its Epidemiologic Follow-Up Study to examine the association between periodontal disease and cerebrovascular accidents. The study found that periodontitis was a significant risk factor for total CVA, in particular, for non-hemorrhagic stroke (Wu et al. 2000).

In addition to diabetes and coronary artery disease, associations have been found between periodontal disease and rheumatoid arthritis and respiratory disease. This is not surprising given the role of periodontal disease in the production of inflammation related proteins. Dissick and colleagues conducted a pilot study of the associate ion between periodontitis and rheumatoid arthritis using multivariate regression and chi square tests. They found that periodontitis was more prevalent in patients with rheumatoid arthritis than in the control group and that patients who were seropositive for rheumatoid factor were more likely to have moderate to severe periodontitis than patients who were RF negative and also that patients who were positive for anti-cyclic citrullinated peptide antibodies were more likely to have moderate to severe periodontitis (Redman et al. 2010). Paju and Scannapeico investigated the association among oral biofilms, periodontitis and pulmonary infections. They noted that periodontitis seems to influence the incidence of pulmonary infections, particularly nosocomial pneumonia in high-risk subjects and that improved oral hygiene has been shown to reduce the occurrence of nosocomial pneumonia. They found that oral colonization by potential respiratory pathogens, for possibly fostered by periodontitis and possibly by bacteria specific to the oral cavity contribute to pulmonary infections (Paju and Scannapeico 2007).

4.1.1.4 Implications for Health Policy

The implications for these findings are profound. Professionally, they suggest that managing patients with chronic illness and periodontal disease will require teamwork and a deeper knowledge base for dentists and for physicians (Mealey and Rose 2008). Dentists will need to be alert for early signs of chronic illness among their patients and physicians will need to be alert for signs of dental disease. Both will need to consider wider treatment options than their specialty indicates. Dentistry and medicine have operated as professional silos in the past. The relationship between dental disease and chronic medical conditions suggests that continued separation is detrimental to patient centered care.

Beyond treatment implications, there are extremely important health policy concerns. If treatment of periodontitis and other dental problems leads to reduced incidence of chronic illness, fewer complications from chronic diseases and reduced morbidity among chronically ill patients, increased access to dental services could significantly reduce health care costs.

The diseases associated with periodontitis are among the most common illnesses, the fastest growing and the most expensive diseases that we treat. A recent Robert Wood Johnson report notes that approximately 141 million Americans have one or more chronic conditions, that the number of people with chronic conditions is expected to increase by 1% per year for the foreseeable future and that the most common chronic conditions include hypertension, disorders of lipid metabolism, upper respiratory disease, joint disorders, heart disease, diabetes, cardiovascular disorders, asthma and chronic respiratory infections (Anderson 2010) (see Fig. 4.1).

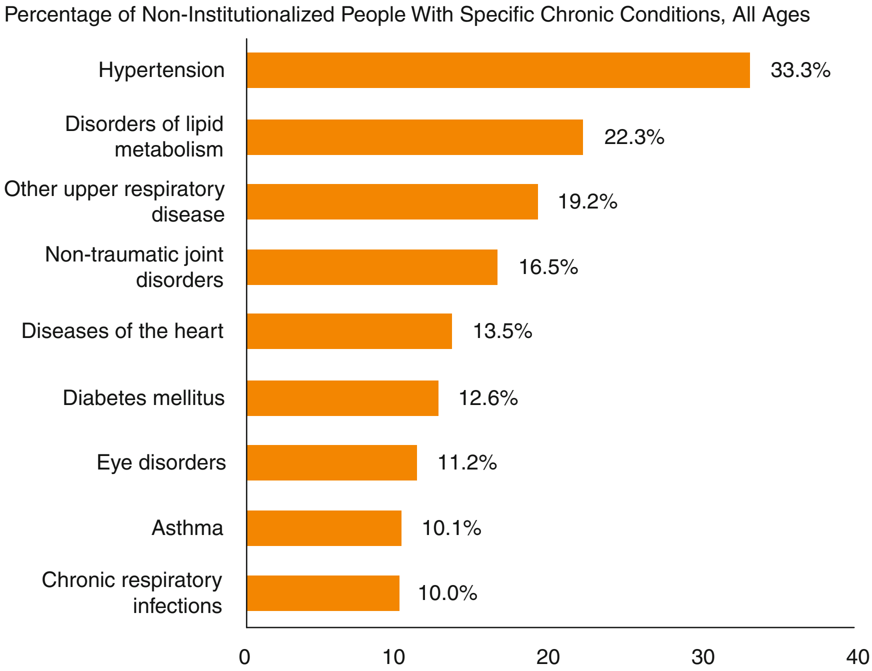


Fig. 4.1 Most common chronic US illnesses. Anderson (2010) (Copyright 2010. Robert Wood Johnson Foundation. Used with permission from the Robert Wood Johnson Foundation)

One in four Americans has multiple chronic conditions. Ninety-one percent of adults aged 65 and older have at least one chronic condition and 73% have two or more of them (Anderson 2010). People with chronic conditions account for 84% of all healthcare spending. Seventy eight percent of private health insurance spending is attributable to the 48% of privately insured persons with chronic conditions. Seventy three percent of healthcare spending for the uninsured is for care received by the one third of uninsured people who have chronic conditions. Seventy nine percent of Medicaid spending goes to care for the 40% of non-institutionalized beneficiaries who have chronic conditions (Anderson 2010) (see Fig. 4.2).

Further, health care spending increases with the number of chronic conditions (Anderson 2010) (see Fig. 4.3). More than three fifths of healthcare spending (two thirds of Medicare spending) goes to care for people with multiple chronic conditions. Those with multiple chronic conditions are more likely to be hospitalized, fill more prescriptions, and have more physician visits (Anderson 2010).

In 2002 the American Diabetes Association estimated direct medical expenditures for diabetes at $91.8 billion: $23.2 billion for diabetes care, $24.6 billion for chronic complications and $44.1 billion for excess prevalence of general medical conditions. Approximately 52% of direct medical expenditures were incurred by people over 65. Indirect expenditures included lost workdays, restricted productivity mortality and permanent disability – a total of $39.8 billion. All told, diabetes was found to be responsible for $160 billion of $865 billion in total

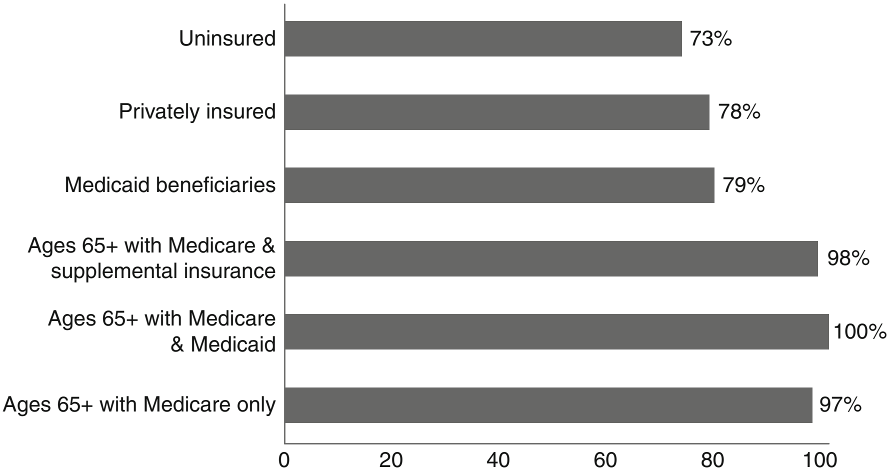
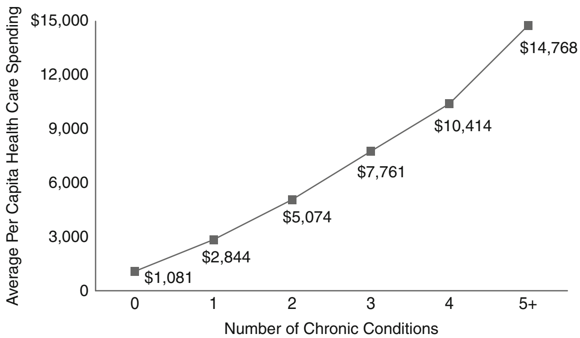


Fig. 4.2 Percentage of healthcare spending for individuals with chronic conditions by type of insurance – 2006. Anderson (2010) (Copyright 2010. Robert Wood Johnson Foundation. Used with permission from the Robert Wood Johnson Foundation)

Fig. 4.3 Per capita healthcare spending and number of chronic conditions – 2006. Anderson (2010) (Copyright 2010. Robert Wood Johnson Foundation. Used with permission from the Robert Wood Johnson Foundation)



expenditures. Per capita medical expenditures totaled $13,000 annually for people with diabetes and $2600 for people without diabetes (Hogan et al. 2002). More recently, Dall and colleagues estimated that the US national economic burden of prediabetes and diabetes had reached $218 billion in 2007, $153 million in higher medical costs and $65 billion in reduced productivity. Annual cost per case was estimated at $2,900 for undiagnosed diabetes and 10,000 for type 2 diabetes (Dall et al. 2010).

The costs of caring for people with diabetes have risen both because the numbers of diabetics has been increasing and because the per capita costs of care have increased. The number of diabetics increased from 5.8 million on 1980 to 14.7 million in 2004 (Ashkenazy and Abrahamson 2006). A recent report by the UnitedHealth Group Center for Health Reform & Modernization provides a dire estimation – that more than 50% of adult Americans could have diabetes (15%) or prediabetes (37%) by 2020 at a cost of $3.35 trillion over the decade. This compares with current estimates of 12% of the population with diabetes and 28% with prediabetes, or 40%. These estimates conclude that diabetes and prediabetes will account for 10% of total healthcare spending in 2020 at an annual cost of $500 billion, up from an estimated $194 billion in 2010 (UnitedHealth Center for Health Reform and Modernization 2010). Average annual spending over the next decade by payer type is $103 billion for private health insurance, $204 billion for Medicare, $11 billion for Medicaid and $16.6 billion for the uninsured.

What about cardiovascular disease and rheumatoid arthritis? Among the top ten health conditions requiring treatment for Medicare beneficiaries in 2006 approximately 50% of beneficiaries suffered from hypertension, 25% from heart conditions, 33% had hyperlipidemia 24% had COPD, 23% had osteoarthritis and 22% had diabetes (Thorpe et al. 2010). The American Heart Association estimates the 2010 cost of cardiovascular disease and stroke to be $324 billion in direct expenditures and $41.7 billion for productivity losses due to morbidity and $137.4 billion in lost productivity due to mortality (present value of lost wages at 3%) (Lloyd-Jones et al. 2010). The Centers for Disease Control estimates that during 2007–2009 50 million Americans had self-reported doctor diagnosed arthritis, 21 million of them with activity limitations (Cheng et al. 2010). Cisternas and colleagues estimated that total expenditures by US adults with arthritis increased from $252 billion in 1997 to $353 billion in 2005. Most of the increase was attributable to people who had co-occurring chronic conditions (Cisternas et al. 2009). The Cisternas study appears to aggregate all medical care expenditures by people with arthritis (which would include expenditures to treat diabetes and cardiovascular disease). An earlier CDC study focused on the direct and indirect costs in 2003 attributable to arthritis that estimated $80.8 billion in direct costs (medical expenditures) and $47 billion in indirect costs (lost earnings) (Yelin et al. 2007).

In short, current cost estimates for direct health care expenditures (excluding productivity losses) related to diabetes are approximately $190 billion, for cardiovascular treatment, $324 billion, and for rheumatoid arthritis, approximately $111 billion (estimating that the $80.8 billion in 2003 costs have grown approximately 6% per year), a total of $625 billion of the $2.6 trillion that will be spent in the US in 2010. Moreover, given current growth in the prevalence of diabetes, the UnitedHealth estimate of $500 million in 2020 spending for diabetes alone is not unreasonable. If health care costs attributable to diabetes, cardiovascular disease and rheumatoid arthritis only increase by 100% over the next decade (even given added demand produced by the aging baby boomer population), annual costs of these chronic diseases will exceed $1.2 trillion in 2020.

If we use the UnitedHealth estimates for the proportions of diabetes costs paid by private insurance (48%), Medicare (38%), Medicaid (6%) and the uninsured (8%) and estimate total costs based on the 2010 studies projecting a 50% increase in 5 years and a 100% increase in 10 years we can obtain an estimate of future costs for treating diabetes, cardiovascular disease and arthritis. Table 4.1 set forth below, summarizes these cost estimates. By 2020 Medicare costs for these chronic illnesses

Table 4.1 US Medical care cost estimates for diabetes, cardiovascular disease and arthritis (millions of dollars)

		2010	2015	2020
	Diabetes	190	285	380
	Cardiovascular	324	486	648
	Arthritis	111	167	222
	Total	**$625**	**$938**	**$1,250**
Private	0.48	300	450	600
Medicare	0.38	238	356	475
Medicaid	0.06	38	56	75
Uninsured	0.08	50	75	100

would be approximately $475 billion. The estimated costs to Medicaid will be approximately $75 billion. The costs for the uninsured will be approximately $100 billion. Any intervention that has the potential to substantially reduce these costs will produce meaningful results.

Unfortunately, even though there had been a substantial numbers of studies that show relationships between dental disease and chronic illness that are have been very few studies that actually test whether improved dental treatment reduces the incidence of chronic illness and complications due to chronic illness. The potential for large health care cost savings through an active and aggressive program of dental care is so large that such studies are clearly indicated.

4.1.1.5 Potential Benefits of an Aggressive Dental Treatment Plan

Suppose, for example, that 10% of all medical care costs required to treat diabetes, cardiovascular disease and arthritis could be avoided through an active aggressive program of dental care.[4] What this would mean is that in 2020 private health insurers could see a $60 billion reduction in healthcare costs, Medicare would see a $47.5 billion reduction and Medicaid pay $7.5 billion reduction. Recent health reform has provided for the issuance of health insurance to the uninsured by state exchanges. Aggressive dental care that saved 10% of costs attributable to diabetes, cardiovascular disease and arthritis could save the exchanges $10 billion per year. And, if greater proportions of costs can be saved or if the 2020 estimates of costs are low, potential benefits will be even larger. Once again, it would be important to know whether aggressive dental care could produce such savings and how much.

[4]Ide and colleagues found that people who were treated for periodontitis incurred 21% higher health care costs than those who were free of periodontal disease (Ide et al. 2007). Similarly, Albert, et al., found medical costs associated with diabetes, cardiovascular disease and cerebrovascular disease were significantly higher for enrollees who were treated for periodontitis than for other dental conditions (Albert et al. 2006). Additional studies of this nature would be important to support a measured approach to expanding dental coverage.

4.1.1.6 Costs of an Aggressive Dental Treatment Plan

So what do we mean by an aggressive dental treatment plan? Suppose we were to provide dental insurance to all Medicare beneficiaries at the level of current private dental insurance coverage and strongly encourage beneficiaries to receive dental treatment. Suppose we were to provide for Medicaid payment for all beneficiaries at the level of current private dental insurance coverage. Suppose health care insurers provided dental coverage in order to reduce their costs and that such coverage was consistent with current private dental insurance coverage. Suppose health insurance companies, understanding the benefits from dental care, were to require their private employer customers to cover the costs of dental care. How much would all of this cost? How would it compare to the benefits that may be available?

In order to estimate the potential costs of providing enhanced coverage for dental care we start use the CMS estimates of national health care spending for dental services and Statistical Abstract of the US estimates for Medicare enrollment, Medicaid enrollment, private health insurance enrollment and uninsured persons. Based on the estimate that half of private employers with health insurance provided dental insurance coverage we estimate that of the private health insurance enrollment one half would have dental insurance coverage and one half would not. Table 4.2 sets forth the national health care expenditures for dental services in millions and enrollment in private dental plans, Medicare, Medicaid, the uninsured without health insurance and dental insurance, the uninsured with health insurance and dual eligibles.

From this we derive a cost per enrollee for private dental insurance, Medicare dental benefits and Medicaid dental benefits. Table 4.2 also sets forth the calculations for 2000–2009. For example, per beneficiary costs in 2009 for private health dental insurance was $494.66. As expected given the lack of Medicare coverage and the low level of Medicaid coverage, per beneficiary expenditures in 2009 were $6.73 for Medicare beneficiaries and $146.75 for Medicaid beneficiaries.

In order to estimate the annual cost of providing full dental coverage to Medicare beneficiaries we subtracted dual eligibles (who receive some dental insurance) from total Medicare enrollees to determine the number of persons who would need coverage. In our 2009 example there were 43 million Medicare beneficiaries including 9 million dual eligibles. Accordingly, the estimates would cover the 34 million Medicare beneficiaries that are not dual eligible at a cost equal to the per capita cost of private dental insurance ($494.66) less amounts that Medicare is already paying for dental services ($6.73 per person). The result provides an estimate of the cost of covering all Medicare beneficiaries for dental services at a level equivalent to private health insurance. Using the 2009 example the cost of providing full dental insurance coverage to Medicare beneficiaries would have been $16.6 billion.

In addition, we used the CMS national health expenditure figures to determine administrative costs for private health insurance, Medicare and Medicaid as a percentage of program expenditures for medical care. We found that the administrative costs of the Medicare program were 6.2% on average for 1966–2009. In order to fully estimate the cost of Medicare dental coverage we added 6.2% to the cost

Table 4.2 Estimated cost to provide full dental coverage

Spending/millions	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Private	31,175	34,158	36,464	37,359	40,472	42,871	45,137	47,836	49,142	49,960
Medicare	81	86	79	70	71	86	103	164	222	290
Medicaid	2,312	3,124	3,467	3,745	4,005	4,229	4,378	4,758	5,818	7,147
Enrollment in millions										
Private dental coverage	101	100	100	99	100	101	101	101	101	101
Medicare	38	38	38	40	40	40	40	41	43	43
Medicaid	30	32	33	36	38	38	38	40	43	49
Uninsured	40	41	44	45	44	45	47	46	46	50
Uninsured w/health cov	101	100	100	99	100	101	101	101	101	101
Dual eligible	12	11	11	11	8	9	9	9	9	9
Per enrollee cost										
Private	310	342	366	378	403	426	448	476	487	495
Medicare	2	2	2	2	2	2	3	4	5	7
Medicaid	78	99	104	105	105	111	114	120	137	147
Pct cost increase										
Private		10.2%	7.2%	3.0%	6.7%	5.8%	5.0%	6.3%	2.2%	1.7%
Medicaid		26.2%	5.6%	0.7%	0.2%	5.3%	3.0%	5.1%	13.7%	7.5%

Cost to cover/millions										
Medicare	7,913	9,268	9,839	10,559	12,635	13,314	13,929	15,340	16,368	16,589
Medicaid	6,835	7,675	8,700	9,696	11,305	12,007	12,764	14,091	14,909	16,943
Uninsured	12,340	14,080	15,978	16,990	17,526	19,091	21,036	21,752	22,527	24,881
Uninsured w/health cov	31,175	34,158	36,464	37,359	40,472	42,871	45,137	47,836	49,142	49,960
Cost incl admin										
Medicare 6.2%	8,404	9,843	10,450	11,214	13,419	14,139	14,792	16,291	17,382	17,618
Medicaid 7.6%	7,354	8,258	9,361	10,433	12,164	12,919	13,734	15,162	16,042	18,231
Uninsured-exchanges 7.6%	13,278	15,150	17,193	18,281	18,858	20,542	22,634	23,405	24,240	26,772
Uninsured w/health cov	33,545	36,754	39,235	40,199	43,548	46,129	48,567	51,471	52,877	53,757

estimates. In 2009, for example the added cost of providing full dental insurance coverage to 34 million Medicaid beneficiaries would have been $17.6 billion.

Similarly, we calculated the per person cost of bringing Medicaid payment for dental services up to the level of private dental insurance. To do this we deducted the per capita amounts provided to Medicaid beneficiaries for dental services from the amounts paid on behalf of private health insurance beneficiaries and multiplied the difference by the number of Medicaid beneficiaries in the US. For example, in 2009 there were 48.7 million Medicaid beneficiaries. The cost of upgrading their dental insurance benefits which have been 48.7 million times $494.66 less $146.75 or $16.9 billion. After adding administrative costs of 7.6% the cost of upgrading Medicaid to private insurance levels in 2009 would have been $18.2 billion.

Health insurers will be in the same position as Medicare and Medicaid regarding dental coverage. If quality dental coverage saves health care costs attributable to diabetes, cardiovascular disease and rheumatoid arthritis then the exchanges will have an incentive to provide quality dental coverage to reduce costs. Accordingly, we estimated the cost of providing dental coverage equivalent to private dental insurance coverage through the exchanges. Again we assume that the costs of such coverage will be equivalent to the number of uninsured persons multiplied by the annual per capita cost of coverage.[5] For the 2009 example, this would reflect coverage for 52 million people at $494.66 per person, a total of $24.9 billion. With administrative costs, the cost of providing dental insurance coverage to the uninsured at a level equivalent to private dental coverage would be $26.8 billion.

Finally, given the evidence that improved dental care has the potential to reduce health care costs private health insurers may wish to expand health insurance to cover dental care.[6] Here, we estimate the cost of providing dental insurance to the 50% of the workforce whose employers currently do not provide dental insurance benefits. Once again, we multiply the number of covered lives by the estimated annual per capita cost. For the 2009 example we estimate 101 million adults will receive dental coverage at $495 per person: $50 billion for dental services and $3.8 billion for administrative costs or a total of $53.8 billion.

Of course, as noted a number of times above, these estimates are based on providing full "universal" dental insurance coverage at levels equivalent to current benefit levels for private dental insurance. It may be that an appropriate package of dental services that deals specifically with periodontitis can be provided for less than the full cost of private dental insurance. Once again, further research should provide better information.[7]

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[5]The health reform law does not attempt to provide coverage to all 52 million people without health insurance. Estimates are that only 31 million people will be covered by the bill. Even though this is the case we prepare our estimates using all 52 million uninsured Americans.

[6]Indeed, the failure of 50% of employers to cover dental services may well constitute a classic externality in the market for health insurance. Internalizing this externality may well provide better efficiency.

[7]It is also possible that dental care for persons with greater incidence of chronic illness as is the case with Medicare beneficiaries may require even higher levels of spending per beneficiary. Again, it would be good to know scientifically if this is the case.

Table 4.3 Estimated medical care costs, expanded dental coverage costs and percent of medical costs that would need to be saved to justify coverage

	Medical care costs	Insurance costs	Percent medical
Private	300	53.8	17.9%
Medicare	238	17.6	7.4%
Medicaid	38	18.2	48.5%
Uninsured	50	26.8	53.6%

4.1.1.7 Comparing Costs and Benefits

As noted in Sect. 6 above, 2010 costs for diabetes, cardiovascular disease and arthritis will be $300 billion for private health insurance, $238 billion for Medicare, $38 billion for Medicaid and $50 billion for the uninsured. Costs of providing "full" dental coverage will be $17.6 billion for Medicare, $18.2 billion for Medicaid, $26.8 billion for the uninsured and $53.8 billion for private health insurance. Given this, if 7.4% or more of the Medicare costs can be "saved" through improved dental care, Medicaid dental insurance will pay for itself and will provide a positive return on investment. See Table 4.3. Similarly, private health insurers could justify providing dental insurance coverage to employees who do not have it so long as they spend 17.9% or more of their chronic care costs for diabetes, cardiovascular disease and arthritis. On the other hand, it would appear that Medicaid expansion would require cost savings of approximately 48% and that health care insurance coverage of the uninsured would require savings of approximately 54% in order to justify coverage. While it is possible, it may not be likely that full dental coverage would be justified for these programs.

Of course, these estimates do not consider indirect costs in the form of lost wages or premature death. These costs are externalities to the health insurance programs. To the extent that they represent a social benefit that a national dental insurance program might internalize, it would be appropriate to consider their impact in the cost-benefit analysis.

In any event, better understanding of the potential for deriving savings in health insurance costs related to chronic diseases like diabetes, cardiovascular disease and arthritis would be crucial to any determination whether to expand insurance coverage for dental care.

4.1.1.8 Expanded Dental Insurance Coverage

Heretofore the case for expanding Medicare coverage to include dental care has taken the form of "benefit" to patients rather than benefit to health insurance programs and society and has been cast in emotional and political terms. For example, Oral Health America grades "America's commitment to providing oral health access to the elderly" (Oral Health America 2003). In truth, there is no American commitment to providing oral health access to any age group, much less the elderly. Rubenstein notes that "at least one commentator has suggested that the dental profession should join with senior citizen groups when the time is right to ask Congress to expand Medicare to cover oral health" (Rubenstein 2005). Rubenstein emphasizes that "calls for action" are "mere words" unless they are accompanied by political actions that health policy professionals and the dental profession must help promote (Rubenstein 2005). Another commentator has suggested that "as soon as the debate over Medicare prescription drug coverage and, the debate to provide dental care coverage for the elderly may soon begin" (Manski 2001). Rubenstein, again suggests that "the dental community must convince Americans, and particularly aging boomers, that oral health is integral to all health, and for that reason, retiree dental benefits are an important issue".

In truth, a decade of deficit spending and public distaste for out of control program costs in the Medicare and Medicaid programs as well as the unpopularity of the process that was used to provide Medicare prescription drug coverage (with perceived abuses by the health insurance and drug lobbies) and national health reform makes it unlikely that the public would be willing to approve expansions in insurance coverage for dental care "for its own sake" or "as the right thing" or to "benefit seniors." What this political climate has produced is an arena in which a good idea that could provide appropriate return on investment for society might well be rejected out of hand based on political history of health insurance coverage. As a result, it is incumbent on policymakers, medical and dental research scientists and health economists to investigate and confirm the potential savings that expansion of dental insurance coverage has the potential to produce and to develop hard evidence regarding potential costs of the expansion prior to, not as a part of, political efforts aimed at dental coverage expansion. A responsible, well informed effort to expand dental coverage may well go far to restore public confidence in the health policy process.

4.1.2 Economics of Clinical Data Integration

Joseph Kilsdonk and Kelly Boggs

4.1.2.1 Introduction

The adage of "putting your money where your mouth is" is often referenced when being challenged about public statements or claims. In this instance, we use it literally. In 2008 health care costs in US were $2.2 Trillion. There have been numerous reports on health disparities, the burden of chronic diseases, increasing healthcare costs and the need for change. Long-term economic benefits associated with the cost of care are dependent upon integrating oral health with medicine. This is particularly true as it relates to the management of those conditions which impact the economics of healthcare the most. As examples, 96% of Medicare costs and 83% of Medicaid costs are in managing chronic health conditions (Partnership for Solutions National Program Office 2004). More than 40% of the U.S. population has one or more chronic condition (Cartwright-Smith 2011) and in 2006, 76% of Medicare spending was on patients with five or more chronic diseases (Swartz 2011). Effective management of health care resources and information are critical to the economic well-being of our healthcare system. We can no longer afford to manage care in isolation. Integration of care between medicine and dentistry holds much promise in terms of reducing the cost of care and an integrated Medical-Dental Electronic Healthcare Record (iEHR) is the vehicle that will lead to downstream cost savings.

4.1.2.2 The Economics of Integrated Decision Making

In the United States the Center for Medicare & Medicaid Services (CMS) has conducted demonstration projects around chronic disease management. Section 121 of the Benefits Improvement and Protection Act of 2000 mandated CMS to conduct a disease management demonstration project. April 1, 2005, as an effort to reduce the cost of care and improve quality associated with chronic diseases, CMS partnered with ten premier health systems to effectively manage chronic diseases in a Medicare Physician Group Practice Demonstration (PGP). It was the first pay-for-performance initiative for physicians under the Medicare program (Center for Medicare and Medicaid Services 2010). It involved giving additional payments to providers based on practice efficiency and improved management of chronically ill patients. Participants included ten multispecialty group practices nationwide, with a total of more than 5,000 physicians, who care for more than 200,000 Medicare beneficiaries (Frieden 2006). The chronic diseases that were targeted were based on occurrence in the population and included diabetes, heart failure, coronary artery disease, and hypertension (Frieden 2006). The partners CMS selected were; Billings Clinic, Billings, Montana Dartmouth-Hitchcock Clinic, Bedford, New Hampshire; The Everett Clinic, Everett, Washington; Forsyth Medical Group, Winston-Salem, North Carolina; Geisinger Health System, Danville, Pennsylvania; Marshfield Clinic, Marshfield, Wisconsin; Middlesex Health System, Middletown, Connecticut; Park Nicollet Health Services, St. Louis Park, Minnesota; St. John's Health System, Springfield, Missouri; University of Michigan Faculty Group Practice, Ann Arbor, Michigan. Under the PGP, physician groups continued to be paid under regular Medicare fee schedules and had the opportunity to share in savings from enhancements in patient care management. Physician groups could earn performance payments which were divided between cost efficiency for generating savings and performance on 32 quality measures phased in during the demonstration as follows: year 1, 10 measures, year 2, 27 measures and years 3 and 4 having 32 quality measures. For each of the 4 years only the University of Michigan Faculty Group Practice and Marshfield Clinic, earned performance payments for improving the quality and cost efficiency of care. A large part of the success of this project was attributed to being able to extract, evaluate, and monitor key clinical data associated with the specific disease and to manage that data through an electronic health record (Table 4.4).

During the third year of the demonstration project Marshfield Clinic, using a robust electronic health record succeeded in saving CMS $23 million dollars; that's one clinic system in 1 year. As a result of such demonstration projects and as of this

Table 4.4 A table of the quality measures from the PGP initiative

Diabetes mellitus	Congestive heart failure	Coronary artery disease	Preventive care
HbA1c management	Left ventricular function assessment	Antiplatelet therapy	Blood pressure screening
HbA1c control	Left ventricular ejection fraction testing	Drug therapy for lowering LDL cholesterol	Blood pressure control
Blood pressure management	Weight management	Beta-Clocker therapy – prior MI	Blood pressure control plan of care
Lipid measurement	Blood pressure screening	Blood pressure	Breast cancer screening
LDL cholesterol level	Patient education	Lipid profile	Colorectal cancer screening
Urine protein testing	Beta-blocker therapy	LDL cholesterol level	
Eye exam	Ace inhibitor therapy	Ace inhibitor therapy	
Foot exam	Warfarin therapy for patients HF		
Influenza vaccination	Influenza vaccination		
Pneumonia vaccination	Pneumonia vaccination		

writing, CMS is looking to establish Accountable Care Organization's as the medical front runners to new care delivery methods for quality and cost control. Accountable Care Organization (ACO) is a term used to describe partnerships between healthcare providers to establish accountability and improved outcomes for the patients. In a CMS workshop on October 5, 2010, Don Berwick, the administrator of CMS, stated "An ACO will put the patient and family at the center of all its activities…" An emerging model of an ACO is the patient-centered medical home (PCMH). PCMH is at the center of many demonstration projects. ACOs were derived from studies piloted by CMS. Since funds provided by CMS, do not cover routine dental care as part of the patient management or quality and cost objectives CMS ACO studies are limited if they become models for the PCMH, due to the exclusion of dental.

More recently, organizations representing the major primary care specialties – the American Academy of Family Practice, the American Academy of Pediatrics, the American Osteopathic Association, and the American College of Physicians – have worked together to develop and endorse the concept of the "patient-centered medical home," a practice model that would more effectively support the core functions of primary care and the management of chronic disease (Fisher 2008). In 2011 Geisinger Health System, Kaiser Permanente, Mayo Clinic, Intermountain Healthcare and Group Health Cooperative announced they will be creating a project called the Care Connectivity Consortium. This project is intended to exchange patient information. Although progressive in their approach their project does not include dental.

These benefits however, are yet to be adapted in the arena of oral health. As of this writing, dentistry remains largely separate from medical reimbursement mechanisms such as shared billing, integrated consults, diagnosis, shared problem lists, and government coverage. For example, CMS does not cover routine dental care. Dentistry is also working to establish its own "dental home" with patients. However to reap the economic benefits of integrated care, a primary care "medical-dental" home is what needs to be created.

According to an Institute of Oral Health Report (2010) it is widely accepted across the dental profession that oral health has a direct impact on systemic health, and increasingly, medical and dental care providers are building to bridge relationships that create treatment solutions. The case for medical and dental professionals' co-managing patients has been suggested for almost the past century, in 1926 William Gies reported that "The frequency of periodic examination gives dentists exceptional opportunity to note early signs of many types of illnesses outside the domain of dentistry" (Gies 1926). As described by Dr. Richard Nagelberg, DDS "The convergence of dental and medical care is underway. Our patients will be the beneficiaries of this trend. For too long, we have provided dental care in a bubble, practicing – to a large degree – apart from other health-care providers. Even when we consulted with our medical colleagues, it was to find out if premedication was necessary, get clearance for treatment of a medically compromised patient, or find out the HbA1c level of a diabetic individual, rather than providing true patient co-management. We have made diagnoses and provided treatments without the benefit of tests, reports, metrics, and other information that predict the likelihood of disease development and progression, as well as favorable treatment outcomes. We have practiced in this manner not due to negligence, but because of the limitations of tools that were available to us" (Nagelberg 2011). Integrated medical/dental records need to be a tool in a providers' toolbox. In the case of Marshfield Clinic, dental was not included in their past CMS demonstration project as dental is not a CMS covered benefit, and thus not part of the demonstration. However, as a leader in healthcare, the Marshfield Clinic recognizes the importance of data integration for both increased quality and cost savings. "Marshfield Clinic believes the best health care comes from an integrated dental/medical approach," said Michael Murphy, director, Business Development for Cattails Software. Integration enhances communication between providers and can ultimately lead to better management of complex diseases with oral-systemic connection, avoidance of medical errors, and improved public health.

While the CMS PGP and other demonstration projects along with independent studies have shown to improve quality and reduce costs through integration, greater results may be afforded if studies are not done in isolation from dental data. In fact, if healthcare does not find a way to manage the systemic nature of the 120 pathogens known to the oral cavity the economic impact and cost savings around chronic disease management will hit a ceiling. The economic opportunity of having clinical data for integrated decision making is readily identified by the insurance industry. The effective management of clinical data around chronic and systemic oral and medical disease as part of an iEHR is the greatest healthcare cost savings opportunity associated with such a tool.

4.1.2.3 Insurance Industry Studies Show the Way

The insurance industry sustains itself through risk management [obtaining best outcomes] using actuarial analysis [data] and controlling costs [reduction of costs] in order to ensure coverage [profitability]. As such they have pursued the economic and outcome benefits of integrated medical – dental clinical decision making. As an example, in 2009 there was a study conducted by the University of Michigan, commissioned by the Blue Cross Blue Shield of Michigan Foundation (2009), the study included 21,000 Blue Cross Blue Shield of Michigan members diagnosed with diabetes who had access to dental care, and had continuous coverage for at least 1 year. With regular periodontal care, it was observed diabetes related medical costs were reduced by 10%. When compounding chronic health complications were also examined, the study showed a 20% reduction in cost related to the treatment of cardiovascular disease in patients with diabetes and heart disease. A 30% reduction in cost related to treatment of kidney disease for patients with diabetes and kidney disease. And a 40% reduction in costs related to treating congestive heart failure for patients with diabetes and congestive heart failure. According to a joint statement by lead researchers, and Blue Cross Blue Shield of Michigan executives, "Our results are consistent with an emerging body of evidence that periodontal disease…it addresses quality of care and health care costs for all Michigan residents."

Also, at the Institute for Oral Health conference in November 2007 Joseph Errante, D.D.S., Vice President, Blue Cross Blue Shield of MA reported that 2003 Blue Cross Blue Shield of Massachusetts claims data showed medical costs for diabetics who accessed dental care for prevention and periodontal services averaged $558/month, while medical costs for diabetics who didn't get dental care were about $702/month (Errante 2007). Similarly insured individuals with cardiovascular diseases who accessed dental care had lower medical costs, $238/month lower than people who did not seek dental treatment (Errante 2007). The cost is $144 less per visit for those diabetics who accessed prevention and periodontal services. Those savings could be translated into access to care or additional benefits for more individuals.

In the case of neonatal health there is similar research. Over 12% of all births in the U.S. are delivered preterm, with many infants at risk of birth defects (Martin et al. 2009). According to a January 2006 statement issued by Cigna, announcing their CIGNA Oral Health Maternity Program, "the program was launched in response to mounting research indicating an increased probability of preterm birth for those with gum disease. These research-based, value-added programs are designed to help improve outcomes and reduce expense" (CIGNA 2006). The program was initially designed to offer extended dental benefits free of charge to members who were expecting mothers, citing "research supporting the negative and costly impact periodontal disease has on both mother and baby." According to research cited by CIGNA, expecting mothers with chronic periodontal disease during the second trimester are seven times more likely to deliver preterm (before 37th week), and the costs associated with treating premature newborns is an average of 15 times more during their first year, and premature newborns have dramatically more healthcare challenges throughout their life. CIGNA also cited the correlation between periodontal disease and low birth weight, pre-eclampsia, gestational diabetes as additional rationale to support extended dental benefits to expecting mothers. Six months later CIGNA initiated Well Aware for Better Health, an extended benefits free of charge program for diabetic and cardiovascular disease patients aimed at "turning evidence into action by enhancing dental benefits for participants in disease management" programs. It is interesting to note, not only does CIGNA offer extended dental benefit to targeted groups, they also reimburse members for any out-of-pocket expenses associated to their dental care (co-pays, etc.)

In 2006, Columbia University researchers conducted a 2-year retrospective study of 116,306 Aetna PPO members with continuous medical and dental insurance, exhibiting one of three chronic conditions (diabetes mellitus, coronary artery disease, and cerebrovascular disease) (Aetna 2008). Researchers found members who received periodontal treatments incurred higher initial per member per month medical costs, but ultimately achieved significantly lower health screening (Episode Risk Group/ERG) risk scores than peers receiving little or no dental care. Convinced by the data and understanding lower risk scores ultimately leads to healthier people and cost savings, Aetna initiated the Dental/Medical Integration (DMI) Program in 2006. Aetna's DMI program offers enhanced benefits in the form of free-of-charge extended benefit dental care to Aetna's 37.2 million Indemnity, PPO and Managed Choice medical plan members, specifically targeting members deemed at-risk, including those who are pregnant, diabetic, and/or have cardiovascular disease and have not been to a dentist in 1 year As a result of various outreach methods during the pilot, 63% of at-risk members who had not been to a dentist in the previous 12 months, sought dental care (Aetna 2008). "The findings from this latest study we conducted continue to show that members with certain conditions who are engaged in seeking preventive care, such as regular dental visits, can improve their overall health and quality of life," said Alan Hirschberg, head of Aetna Dental (Aetna 2008).

Delta Dental of Wisconsin understands the connection between oral and systemic health and has created a program that is designed to offer members with certain chronic health conditions the opportunity to gain additional benefits. More than 2,000 groups now offer Delta Dental of Wisconsin's Evidence-Based Integrated Care Plan (EBICP) option (Delta Dental of Wisconsin 2011). EBICP provides expanded benefits for persons with diseases and medical conditions that have oral health implications. These benefits include increased frequency of cleanings and/or applications of topical fluoride. They address the unique oral health challenges faced by persons with these conditions, and can also play an important role in the management of an individual's medical condition. EBICP offers additional cleanings and topical fluoride application for persons who are undergoing cancer treatment involving radiation and/or chemotherapy, persons with prior surgical or nonsurgical treatment of periodontal disease and persons with suppressed immune systems. The EBIC offers additional cleanings for persons with diabetes and those with risk factors for IE, persons with kidney failure or who are on dialysis and for women who are pregnant.

The iEHR provides the insurance industry in partnership with the healthcare industry an integrated tool to facilitate these health and subsequently economic outcomes across medicine and dentistry.

4.1.2.4 Economic Benefits of Increased Efficiency and Patient Safety Through iEHR

In addition to the anticipated savings through better outcomes using integrated clinical data, an example of a positive economic outcome associated with an integrated record as related to increased efficiency and patient safety is found in the United States Veterans Administration (VA) hospitals and clinics. The VA is one of the few institutions that have implemented the shared electronic medical–dental record successfully. The VA has the ability to be the "one stop shop" for their patients. An April 2010 press release published on the Department of Veterans Affairs website highlighted the success of VA's health information technology in terms of cost reductions and "improvements in quality, safety, and patient satisfaction" (Department of Veterans Affairs 2010). The press release spotlighted a recent study conducted by the public health journal, Health Affairs, which focused on VA's health IT investment from 1997 to 2007. The study confirmed that while VA has spent $4 billion on their technology initiative, a conservative estimate of cost savings was more than $7 billion. After subtracting the expense of the IT investment, there was a net savings of $3 billion for the VA during the 10 years covered by the study (McBride 2011). Furthermore, the study estimated that "more than 86 percent of the savings were due to eliminating duplicated tests and reducing medical errors. The rest of the savings came from lower operating expenses and reduced workload." Independent studies show that the VA system does better on many measures, especially preventive services and chronic care, than the private sector and Medicare. VA officials say "its [integrated] technology has helped cut down hospitalizations and helped patients live longer" (Zhang 2009).

Recently, the Journal of Obstetrics and Gynecology reported on a tragic loss of life due to the systemic nature of oral health. A study found oral bacteria called Fusobacterium nucleatum was the likely culprit in infecting a 35-year-old woman's fetus through her bloodstream (Carroll 2010). The doctors determined that the same strain of oral bacteria found in the woman's mouth was in the deceased baby's stomach and lungs. Integrated records would provide critical data to the Obstetrician including oral health issues and when the patient had her last dental exam. How does one measure the economic impact of a life not lived and another derailed by such tragedy?

In a randomized controlled study, Lopez et al. (2005) determined that periodontal therapy provided during pregnancy to women with periodontitis or gingivitis reduced the incidence of preterm and of low birth weight. The institute of Medicine and National Academies estimate that preterm births cost society at least $23billion annually (Albert et al. 2011). Data integration of the iEHR enables the effective management between the dentist and obstetrician to ensure proper periodontal therapy has been provided during pregnancy. Such management based on the Lopez et al. study, will have direct impact in reducing the prevalence per preterm births leading to reduced health care costs.

There have also been studies indicating a correlation between poorer oral hygiene or deficient denture hygiene and pneumonia or respiratory tract infection among elderly people in nursing homes or hospitals (Rosenblum 2010; Ghezzi and Ship 2000; Scannapieco 2006). One such study of 141 elderly persons in two nursing homes in Japan (Adachi et al. 2002) concluded that "the number of bacteria silently aspirating into the lower respiratory tract was lower in the group who received professional oral care, which resulted in less fatal aspiration pneumonia in that group." Over the 24 month period of the study, of the 77 patients receiving professional oral care, 5% died of pneumonia versus 16.7% of the 64 patients that died of the same cause who maintained their own oral hygiene. Lack of access is certainly a key factor to consider. However, lack of available data respective to the interrelationship between oral health and systemic health also contributed to the apathy in these cases.

As identified above, complications are correlated to cost. As conditions compound, costs go up. Marshfield Clinic, as part of their iEHR is creating a shared problem list that identifies both oral and medical conditions and history to recent visits and medication lists for monitoring at point of care [be it a medical or dental visit], such cross access to clinical data and care management milestones serves as a tool to prevent conditions from compounding and escalating costs such as those described above.

4.1.2.5 Other Areas of Economic Impact Relative to iEHR Clinical Data

Several other areas of economic impact will be seen as iEHR's become broadly deployed. Some of these are listed as follows:

- Medication management. A great deal of provider and allied support time is spent obtaining medication information between dentistry and medicine [and vice versa] including current medications, contraindications, tolerances, etc. Marshfield Clinic Cattails software has created a dashboard that readily identifies this for both the medical and dental providers. Not is time saved but chances for complications or escalation of conditions is reduced [both of which impact cost]. For example an integrated record allows medical providers treating respiratory infections to include or exclude oral flora as the possible source of the infection which would lead to more knowledgeable prescribing decision on the antibiotic used.
- Coordination of care has a direct impact on cost for the system and the patient. For example, in 2008 55.6% of the US population aged 2 years and older that was diagnosed diabetes had been to the dentist in the past year (Healthy People 2020 (2010)). The US government's program Healthy People 2020 includes an initiative to increase the proportion of people with diagnosed diabetes who have at least an annual dental examination. The American Diabetes Association recommends that diabetic patients be seen semi-annually and more if bleeding gums or other oral issues are present. The American Diabetes Association also recommends the consultation between the dentist and doctor to decide about possible adjustments to diabetes medicines, or to decide if an antibiotic is needed before surgery to prevent infection. The target from the Healthy People 2020 is a 10% improvement at 61.2%. Integrated medical/dental records could allow for the coordination of efforts between providers to include communication of treatment plan and services leading to quicker resolution, increased patient compliance, and less patient time away from work or home and potentially less travel.

- Similarly, integrated records also create a platform to integrate clinical appointing between medicine and dentistry. As such, combative patients or severely disabled patients needing anesthesia in order for care to be delivered can be treated with one hospital sedation vs. multiple sedations. Family Health Center of Marshfield, Inc. (FHC) Dental Clinics shares an iEHR with Marshfield Clinic and uses it integrated scheduling feature to complete dental care, lab work, ENT care, woman's health, preventive studies, all in one visit.
- Follow up care management can be more focused and coordinated. For example, without the knowledge or dental conditions, medical providers could spend months attempting to control diabetes with periodontal disease. However, with access to an iEHR, the practitioner or allied care manager can determine patient's oral health status immediately to determine possible influence of periodontal disease.
- Similarly an iEHR with a shared patient data dashboard brings to light history and physical examination data without having to have patients be the historian to their physician on their last dental visit or for the dentist to have to rely on the patient's recall of medications or medical diagnosis. For example, if an integrated record saved providers 5 min per hour of patient care, that would be 40 min per day. Imagine giving a physician or dentist 40 min more a day. In a capitated system, this allows for more patients to be seen in a day for roughly the same amount of expenditure. In a production based clinic this allows more patients to be seen and more charges per day. In either case, the investment into informatics is covered. In an underserved area, more patients get care quicker, which creates the opportunity for quicker resolution, which can lead to a healthier society, which in turn may lead them back to a productive livelihood sooner.
- An iEHR results in one system for acquisition, orientation, training and support. PC based owners who also own a Mac and Mac owners who also have to operate a PC can relate. Need we say more? Imagine if your PC function just like a Mac [or your Mac function just a PC]. No cross learning of software quirks. Not having to purchase two separate units to begin with. Reduced costs, increased space. Not having to jump from one computer to the other computer to get data from one data from another to create a report. Not having to call two separate computer companies for service or updates.
- Third Party Coordination. Having an iEHR creates a platform for interfacing with third party payers. A common system and language for timely reimbursement. In part, the result of an iEHR is driving the diagnostic coding for dentistry. Such an integrated interface provides a tool to bridge with healthcare payors that historically kept payment as segregated as the oral and medical health professions. The iEHR overcomes that limitation. Timely payment, consolidation of payment, expansion of covered patient and provider benefits based on clinical integration, and a viable system for interfacing are all potential economic benefits of iEHR clinical data.
- The iEHR creates new horizons for research that will lead to cost saving discoveries. As example, knowing the benefits of research, Marshfield Clinic Research Foundation (MCRF) has created an Oral and Systemic Health Research Project

(OSHRP). The creation of OSHRP, led by Dr. Murray Brilliant, will allow MCRF to capitalize on its existing and growing strengths in the areas of complex disease interactions and Personalized Health Care (PHC) to advance oral health and the health of the rest of the body. The OSHRP has three specific goals:

  – Understand the connections between oral and systemic health (diabetes, heart disease, pre-term births)
  – Understand the causes of oral diseases and determine the effect of genetics, diet, water source (well/city + fluoridation) and microbiome.
  – Understand how improving oral health aids systemic health (comparative effectiveness) and bring Personalized Health Care (PHC) to the dental arena.

- The OSHRP research resource will be unique in the nation. As MCRF has done with other projects, it will share this resource with qualified investigators at other academic institutions both within and outside of Wisconsin. OSHRP will advance scientific knowledge, improve healthcare and prevention, reduce the cost of oral healthcare, and create new economic opportunities. Such knowledge will have a direct economic impact on the cost of care and care management.
- The iEHR creates an ability to have an integrated patient portal to comprehensively maintain their health. Portals are becoming more and more popular in the healthcare industry as a means to helping maintain compliance with care management recommendations and preventative procedures. Portals provide patents a tool to stay up to date on their care and recommendations. Portals can take iEHR clinical data, adapt it through programming, and provide creative visual reinforcement for patients as they monitor their health status. The more patients engage in owning their health status, the more preventative services are followed through with. The more medicine and dentistry can leverage the prevention potential [which insurance companies have come to realize] the more likely costly conditions can be avoided.

4.1.2.6 Conclusion

The link between oral health and systemic health is well documented. The separation of dental and medical is not a sustainable model in modern healthcare delivery. A new model of integrated care is necessary. Aristotle said, "The whole is greater than the sum of its parts." Increased access to combined medical and dental histories and diagnosis at the providers' fingertips makes vital information available. Shared diagnosis between physicians and dentists could aid in formulating interventions and to accelerate decision making abilities by allowing for prioritizing of medical/dental procedures. Clinical management and treatment of the patient would be expedited with immediate access to both records. Quality could be improved through a complete picture of the patient through the dashboard. All of which have a direct or indirect economic benefit.

The iEHR will be the tool that facilitates such delivery and the studies and scenarios described in these pages point to significant economic benefits to patients, payors, and providers. If increased access, multi-provider monitoring, shared problems lists with enhanced decision making abilities from iEHR could reduce healthcare costs. The greatest cost reduction will be with using the iEHR to manage chronic disease. A combined dental-medical electronic record with a shared data informatics platform is most likely to yield the best long-term economic solution while maintaining or enhancing positive patient outcomes.

4.2 Provider Viewpoints

This section reveals viewpoints from a variety of medical and dental providers. One section focuses on optimal use of ophthalmic imaging, which should show how that the challenges of clinical data integration go beyond those encountered in the effort to bring oral health and systemic health together.

4.2.1 Integration of Pediatric Medical and Pediatric Dental Care

Wendy E. Mouradian, Suzanne Boulter, Paul Casamassimo,
and Valerie J. Harvey Powell

Oral health is an important but often neglected part of overall health. Historically separate systems of education, financing and practice in medicine and dentistry fuel this neglect, contributing to poorer health outcomes for vulnerable populations such as children, while increasing costs and chances for medical error for all patients. Advances in understanding the impact of oral health on children's overall health, changing disease patterns and demographic trends strengthen the mandate for greater integration of oral and overall healthcare, as reviewed in two recent Institute of Medicine reports (IOM 2011a, b). The pediatric population could realize substantial benefit from oral disease prevention strategies under a coordinated system of care enhanced by integrated electronic health records (EHR). This approach would benefit all children but especially young children and those from low socioeconomic, minority and other disadvantaged groups who are at higher risk for oral disease and difficulties accessing dental care.

This section focuses on the pediatric population and the need for close collaboration of pediatric medical and dental providers. First we consider how a child's developmental position and their parents' level of understanding might affect oral health outcomes. Next we address the importance of children's oral health and the urgency of seizing missed opportunities to prevent disease. We then briefly outlines some steps to preventing early childhood oral disease utilizing some of the many health providers that interact with families. Finally we examine one pediatric hospital's approach to choosing an integrated EHR technology.

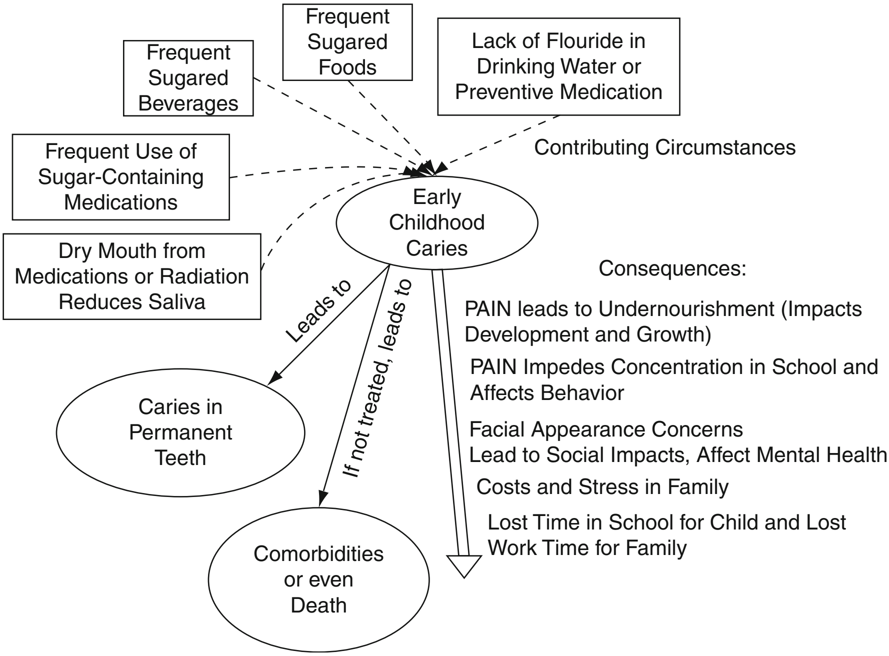

Fig. 4.4 Delivering oral healthcare to a child

4.2.1.1 A Childs-Eye View of Oral Health

Children have unique characteristics which distinguish their needs from those of adults. Children's developmental immaturities may increase their risks for poor oral health outcomes (Fig. 4.4). For example, a child…

- May not be able to communicate pain, discomfort and other symptoms,
- May not recognize a particular sensation or lesion as a symptom or sign of disease,
- May not grasp the consequences of poor oral health habits,
- May not realize the consequences of consuming quantities of sugared foods or beverages,
- Likely does not realize the consequences of chronic use of sugared medications,
- Does not understand the long-term consequences of early childhood caries,
- Does not know the potential for systemic spread of disease from a toothache, or for liver damage due to overuse of acetaminophen or other analgesics,
- Must learn good oral health habits from parents/caregivers
- Must trust parents/caregivers to judge the appropriateness of and necessity for health care, and
- Does not understand how the health care system works and cannot access care without an adult.

All children, but especially young children, are limited in their ability to care for their own health and must depend upon adults. A child's parent/caregiver may also lack basic oral health knowledge and an awareness of their child's oral health needs, and/or suffer from poor oral health themselves. Low oral health literacy is prevalent among patients and health professionals alike in America; individuals of low socioeconomic status or from ethnically diverse backgrounds may be at particular risk for low oral health literacy (IOM 2011a). Without appropriate education, a parent….

- May not correctly interpret a child's symptoms or signs of oral disease
- May not know that caries is an infectious disease that can be spread to a child by sharing spoons, for example,
- May not know the potential value of chewing gum with Xylitol,
- May not fully grasp the importance of good oral health hygiene habits,
- May not grasp the consequences of a child consuming quantities of sugared foods or beverages,
- May have difficulty controlling the child's consumption of sugared foods or beverages in or out of the home,
- May not realize the consequences of chronic use of sugared medications,
- May not know the potential for systemic spread of disease from a toothache, or for liver damage due to overuse of acetaminophen or other analgesics,
- May not grasp the long-term consequences of early childhood caries,
- May live in a community without fluoride in the tap water and not know about alternative sources of fluoride,
- May overlook oral health due to the stress of living in poverty,
- May be fearful of dentists or oral health care due to their own experiences,
- May have difficulty locating a dental provider accepting public insurance, or have other problems navigating the health care system.

Parents in turn depend on access to medical and dental providers with current understanding of the most effective ways to prevent caries and promote the child's oral and overall health. An important element in helping families is the provision of culturally-sensitive care to a diverse population. Children are the most diverse segment of the population with 44% from minority backgrounds compared with 34% of the overall population (US Census Bureau 2010).

The separation of medical and dental systems and the lack of shared information can create additional barriers for families, especially for those with low health literacy or facing linguistic or cultural barriers. All pediatric health professionals have increased ethical and legal responsibilities to promote children's health, including advocacy for them at the system level (Mouradian 1999).

4.2.1.2 Children's Oral Health: Impact of Missed Opportunities

Although many factors can influence children's oral health outcomes, caries is largely a preventable disease. Despite this, national trends and other data on children's oral health attest to this persistent national problem (Mouradian et al. 2009). Some important facts include the following….

- Caries is the most prevalent chronic disease of childhood,
- Caries is a preventable disease unlike many chronic diseases of childhood,
- Yet according to (NICDR 2011) 42% of children 2–11 have had dental caries in their primary teeth; 23% of children 2–11 have untreated dental caries. Further, "21% of children 6–11 have had dental caries in their permanent teeth; 8% of children 6–11 have untreated decay." Overall "[c]hildren 2–11 have an average of 1.6 decayed primary teeth and 3.6 decayed primary surfaces,"
- The latest epidemiologic evidence shows increasing rates of caries for youngest children, reverse from the Healthy People 2010 goal of decreasing caries. According to (NICDR 2011), overall "dental caries in the baby teeth of children 2–11 declined from the early 1970s until the mid 1990s. From the mid 1990s until the most recent (1999–2004) National Health and Nutrition Examination Survey, this trend has reversed: a small but significant increase in primary decay was found. This trend reversal was more severe in younger children."
- Disparities in children's oral health and access to care persist by age, income level, race and ethnicity, and parental education level (Edelstein and Chinn 2009). Of concern, the latest increase was actually in a traditionally low-risk group of young children (Dye and Thornton-Evans 2010).
- The human and economic costs of early childhood caries are substantial (Casamassimo et al. 2009). According to Catalanotto (2010), health consequences include…
  - extreme pain,
  - spread of infection/facial cellulitis, even death (Otto 2007)
  - difficulty chewing, poor weight gain
  - falling off the growth curve (Acs et al. 1999)
  - risk of dental decay in adult teeth (Broadbent et al. 2005; Li and Wang 2002)
  - crooked bite (malocclusion)
- Children with special health care needs (CSHCN) may be at higher risk for oral disease and difficulties accessing care. Analyzing data from the National Survey of Children with Special Health Care Needs, (Lewis 2009) found that "CSHCN are more likely to be insured and to receive preventive dental care at equal or higher rates than children without special health care needs. Nevertheless, CSHCN, particularly lower income and severely affected, are more likely to report unmet dental care need compared with unaffected children." Children who were both low-income and severely affected had 13.4 times the likelihood of unmet dental care needs,
- Dental care is the highest unmet health care need of children; 4.6 million children had unmet dental care needs because families could not afford care compared with 2.8 million with unmet medical needs for the same reasons (CDC 2008),
- According to the National Survey of Children's Health, children are 2.6 times as likely to lack dental as medical insurance (Lewis et al. 2007),

- There is evidence that children who get referred to a dentist early may have lower costs of care and disease. Savage et al. (2004) reported that children "who had their first preventive visit by age 1 were more likely to have subsequent preventive visits but were not more likely to have subsequent restorative or emergency visits" and concluded that preschool "children who used early preventive dental care incurred fewer dentally related costs,"
- Ramos-Gomez and Shepherd (1999), in their "Cost-effectiveness Model for Prevention of Early Childhood Caries," conclude that preventive ECC interventions could reduce ECC by 40–80% for a particularly vulnerable population of children, and that part of the costs of interventions will be offset by savings in treatment costs.

As these facts convey, and the deaths of more than one child from consequences of untreated caries make painfully clear, there is an urgent need for more attention to the oral health needs of children. A more coordinated system for oral health care including integrated EHR would be an important advance.

4.2.1.3 A Model for Intervention: Creating a System of Care

A glance at Table 4.5, an ideal model, reveals that intervention should begin before birth and that a range of medical and oral health professionals can contribute to the child's oral health. Early intervention is necessary because of the transmissibility of cariogenic bacteria from mother/caregiver to infant, and importance of oral health practice in preventing disease. The following professionals may be involved:

- *pediatric medical provider*family physician
  - pediatrician
  - pediatric nurse
  - nurse practitioner in pediatric/family practice
  - physician assistant in pediatric /family practice
- obstetrician
- obstetric nurse/nurse midwife
- general dentist
- pediatric dentist
- pediatric dental hygienist
- pharmacist
- other appropriate allied health professionals

The availability of some of these professionals can be affected socioeconomic status, health insurance, place of residence, or by a child's special health care need.

One obvious limitation on developing a "relay" as in Table 4.5, with a "hand-off" from family care to obstetric care to pediatric care is the education of the medical providers. As part of pre-conception and perinatal healthcare, providers should address oral health, but may lack the knowledge to do so. Additionally, as noted by Ressler-Maerlaender et al. (2005), "some women may believe that they or their

Table 4.5 Timeline of some oral health interventions to prevent early childhood caries (ECC) – birth to 3 years age (Marrs et al. 2011; Lannon et al. 2008; Han et al. 2010; Ezer et al. 2010; AAP 2008; Mouradian et al. 2000)

Child's age	Intervening professional(s)	Intervention, rationale, conditions and strategy
Planning conception, prenatal and perinatal	Family physician Obstetrician/nurse midwife Obstetric nurse General dentist	The physician and/or obstetric provider educates mother-to-be about good maternal oral hygiene and infant oral health issues, including transmissibility of caries. Mother's dentist assesses and treats caries, gingivitis or other oral health problems and educates the mother-to-be
Neonatal	Obstetric nurse	Obstetric nurse advises new mother to chew Xylitol gum, limit salivary contact between mother and infant, and help child avoid sugar intake (exposure) while asleep and from common sugar sources (medicines, sugared water, bottle feeding on demand at night with fluid other than water – following tooth eruption, certain foods), and to schedule dental exam at 1 year age
6 months	Pediatric medical provider	First dental examination recommended by AAPD *when the first tooth comes in, usually between 6 to 12 months*
	Pediatric/general dentist	Educate mother about optimal fluoride levels
	Dental hygienist or other allied dental professional	Anticipate window of infectivity: 17–36 months; period when deciduous teeth are erupting Caries- risk assessment tool[1] Presence of disabilities and other special health care needs may increase child's risk of disease
9 months	Pediatric medical provider refers to establish dental home for child	Assure child has dental home by 1 year
1 year	Pediatric medical	Pediatric or general dentist able to provide infant oral health care may not be available in rural areas or for families of lower socioeconomic status
	Professional provider delivers preventive oral healthcare if no pediatric /general dentist is available	Caries risk assessment tool1 Anticipate that ECC can affect children as soon as teeth erupt

(continued)

Table 4.5 (continued)

Child's age	Intervening professional(s)	Intervention, rationale, conditions and strategy
2 years	Pediatric medical provider	Assure child has dental home
	Pediatric dentist	If no dental home, then administer oral health risk assessment
	Pediatric dental hygienist	Child may begin to use fluoride toothpaste with supervision
		Pediatric preventive care vital if pediatric dental care not available
		If primary water source is fluoride-deficient, consider fluoride supplementation or fluoride varnish
3 years	Pediatric medical provider	Assure child has dental home
	Pediatric/general dentist	Pediatric preventive care vital if pediatric dental care not available
	Pediatric dental hygienist	If primary water source is fluoride-deficient, consider fluoride supplementation or fluoride varnish

[1]Caries-Risk Assessment Tool (CAT) developed by the AAPD http://www.mchoralhealth.org/pocketguide/cat1.html

fetus could be harmed by treatment." During the prenatal visit, health care providers should:

1. assess the woman's oral health status, oral health practices, and access to a dental home;
2. discuss with the woman how oral health affects general health;
3. offer referrals to oral health professionals for treatment;
4. educate the woman about oral health during pregnancy, including expected physiological changes in the mouth and interventions to prevent and relieve discomfort; and
5. educate the woman about diet and oral hygiene for infants and children and encourage breastfeeding

New York and California have developed state guidelines for perinatal oral health to educate providers and patients (California Dental Association 2010; New York State Department of Health 2006).

A combination of anticipatory guidance, with continuity from prenatal and perinatal care to pediatric care, can help move infant oral health from "missed opportunities" to "seized opportunities." Others who may be of assistance to families in closing these gaps are professionals at the Women, Infants and Children's (WIC) supplemental nutrition program, Early Head Start/Head Start and Neurodevelopmental/Birth to Three programs. Together medical, dental and community professionals can help create a system of care to improve maternal and child oral health.

4.2.1.4 Capacity of the Workforce to Prevent Childhood Caries

For the envisioned model in Table 4.5 to be realized, the mother requires access to a general dentist with accurate information on her oral health during pregnancy and on her infant's oral health, including the need for an early dental visit. The mother and child then need access to a pediatric medical provider who will provide oral health screening/counseling, and who will guide the family to establishing the child's dental home by age 1. Success in dental referral requires access to a pediatric or general dentist willing and able to provide infant oral health. (dela Cruz et al. 2004), in a discussion of the referral process mentioned that among the factors in assessing the likelihood of a dental referral were the medical providers' "level of oral health knowledge, and their opinions about the importance of oral health and preventive dental care."

Since young children are much more likely to access medical than dental care, the medical provider plays an important role in promoting children's oral health. (Catalanotto 2010) recommends, as part of a pediatric well child checkup:

- an oral screening examination,
- a risk assessment, including assessment of the mother's/caregiver's oral health,
- application of fluoride varnish

- anticipatory guidance (parental education) including dietary and oral hygiene information,
- attempted referral to a dental home.

The AAP recommends that child healthcare providers be trained to perform an oral health risk assessment and triage all infants and children beginning by 6 months of age to identify known risk factors for early childhood caries (ECC). The oral health component of pediatric care is integrated into the AAP's "Recommendations for Preventive Pediatric Health Care (Periodicity Schedule)" (AAP 2008).

To what extent are medical and dental and providers aware of recommendations for a first dental visit for a child by age one, as recommended by the AAP, the American Academy of Pediatric Dentistry (AAPD), and the American Dental Association? (Wolfe et al. 2006) reported that 76% of licensed general dentists in Iowa were familiar with the AAPD age 1 dental visit recommendation and that most obtained the information through continuing education; 11% believed that the first dental visit should occur between 0 and 11 months of age. However, according to (Caspary et al. 2008), when pediatric medical residents were asked the age for the first dental visit, the average response was 2.4 years, while 35% reported received no oral health training during residency. In a national survey of pediatricians (Lewis et al. 2009) reported that less than 25% of had received oral health education in medical school, residency, or continuing education. Finally (Ferullo et al. 2010) surveyed allopathic and osteopathic schools of medicine and found that 69.3% reported offering less than 5 h of oral health curriculum, while 10.2% offered no curriculum at all.

Other workforce considerations relevant to preventing early childhood caries include the training of dentists in pediatric oral health (Seale et al. 2009), the number and diversity of the dental workforce, the number of pediatric dentists, and the use of alternative providers such as dental therapists, expanded function dental assistants and dental hygienists (Mertz and Mouradian 2009; Nash 2009).

Examples of integrated care models do exist, such as that presented by (Heuer 2007) involving school-linked and school-based clinics with an "innovative health infrastructure." According to Heuer, "Neighborhood Outreach Action for Health (NOAH)" is staffed by two nurse practitioners and a part-time physician to provide "primary medical services to more than 3,200 uninsured patients each year" in Scottsdale, Arizona. Heuer counts caries among the "top ten" diagnoses every year.

Mabry and Mosca (2006) described community public health training of dental hygiene students for children with neurodevelopmental/intellectual disabilities. They mentioned that the dental hygiene students had worked together with school nurses and "felt they had impacted the school nurses' knowledge of oral disease and care."

4.2.1.5 Paper Versus EHR: Planning Pediatric EHR Acquisition: the Decision to Acquire an integrated EHR

As pediatric clinicians (both medical and dental) work more closely together, they require appropriate EHR systems that integrate a patient's medical and dental records. Following is a set of local "best practices" from Nationwide Children's Hospital in Columbus, Ohio, which may help other children's hospitals in planning acquisition of an integrated pediatric EHR system. Integrated (medical-dental) EHR technologies are becoming more widely available outside the Federal government sector (see integrated models E1 and E2 in Fig. 1.3). Nationwide Children's 'drivers' for the acquisition process were, in 2011:

1. *Minimize registration and dual databases*. Patient registration takes time and requiring both a stand-alone dental *and* a medical patient registration inhibits cost-effective flow of services. Integration allows for the use of single demographics information for all clinics in the comprehensive care system serving the patient. Clinicians always have an updated health history on patients, if they have been a patient of record. If not, and for a dental clinic that sees walk-ins, a brief "critical" dental health history can be completed on paper by a parent and scanned into the eMR. In designing an integrated medical-dental record for patients of record, the system can sort essential health history elements into a brief focused dental history without the detail needed by other medical specialty clinics. Kiosk-driven electronic health histories for those children who are new to clinic similar to those used in airline travel could be considered if feasible in busy clinics.
2. *For charting, no more key/mouse strokes than with paper*. Some commercial dental record products try to accomplish too much. Moving from paper to electronics should be driven in part by efficiencies. The tooth chart, which is an essential part of any dental record, must be such that examination findings can be transferred quickly and accurately to either paper or electronic capture. A helpful exercise is visualization of the functionality of the charting process, including both the different types of entries (caries, existing restorations and pathology) and how these are entered in the paper world.

   If charting will be able to be used for research the system should be able to translate pictures to numerical values, often a complex programming function. Dental practitioners and faculty may want to use drawings of teeth or graphics of surfaces because that is their current comfort level. A true digital charting is possible with no images of teeth, but some habits are hard to change.
3. *Maximizing drop downs with drop down building possible*. Duplication of paper chart entries using drop downs which can be upgraded as more clinical entities are found is a staple of an EMR. The paper process usually relies on a clinician's wealth of medical-dental terms since inclusion of every possible, or even the most common findings, is prohibitive on a paper chart. The EMR drop down requires front-end loading of the most common clinical findings with opportunity for free-hand additions. Being able to add terms to any drop down is a needed capability.
4. *Don't design a system for uncommon contingencies, but for your bulk of work*. A pediatric dental record should be primarily designed around dental caries, with secondary emphases on oral-facial development (orthodontics) and a lesser capability to record traumatic injuries and periodontal findings. These second and third level characteristics can be hot-buttoned and should not drive the design of the basic system which is caries charting for 98% of our patients. Sadly in most

dental schools, the chart is slave to every teaching form, few of which ever exit with the DDS into practice! These forms may have little relationship to patient care and only create “signature black holes” that need to be addressed, usually *after* treatment is completed.

5. *Progress notes should be designed for the routine entries with free-hand modification possible*. Student learners tend to write too much and a carefully crafted progress note format with standard entries in required fields helps patient flow and record completion. In federally funded clinics and residencies, attending reconciliation of student/resident service delivery is a compliance requirement. A well-designed EMR system can “stack” required co-signing tasks on a computer screen, offer standard entries as well as free-hand options, and create a process far faster than paper records for an attending’s validation (same as reconciliation?).
6. *Tie examination results to treatment planning and treatment planning into billing*. A good system allows easy transfer of clinical findings needing treatment into some problem “basket” and ideally in a tabulated format. An alternative is a split screen that allows a clinician to visualize clinical findings, radiographic findings while compiling a treatment plan. Again, in clinical settings where compliance to Medicaid/Medicare regulations is required, the design of the record should give attention to auditing principles and security. A good EMR system allows portals of entry for billing and compliance personnel.
7. *Plan for users of different skill levels and different periods of exposure*. The teaching hospital or dental school environment often involves learners and attendings with varying skill levels and computer experience who may be there for brief periods of time. This reality adds significant security and user-friendliness issues. Some medical record systems are far too complex for short-term or casual users. A well-integrated medical-dental EMR allows navigation of the depths of the medical side should a user want to explore, but should focus on the dental portion. Some suggestions in design:

   - Initial opening or logging into the dental portion for dental users, rather than opening into the medical portion,
   - Clearly indicated options for exploration of medical portions,
   - Orientation of major dental component (examination, radiographs, treatment plan) in a logical dental treatment flow to replicate the way dentistry works rather than trying to reshape dentistry’s normal flow to the record,
   - Minimization of seldom-used functions on the main dental screen, such as specialty medical clinics, old laboratory tests and hyperfunctionalities like letter writing,
   - Clear identification of existing non-caries dental portions like orthodontics or trauma, so a novice user need not randomly search to see if a patient has any of these records.

Unfortunately, many pediatric hospitals do not yet have an EHR system that supports convenient communication among a pediatric patient’s medical and dental providers. Evidence of this state of affairs was provided unintentionally by

(Fiks et al. 2011). Some pediatric hospitals may have an awkward mix of systems serving physicians, dentists, and orthodontists and their shared patients.

4.2.1.6 Summary

This section demonstrates how closely medical and dental professionals must collaborate to deliver appropriate oral health care for infants and children. Such collaboration is especially important given the developmental vulnerabilities of children and the urgency of the oral health needs of many children, especially those from underserved populations. Collaboration is made more difficult by the long-standing separation of medical and dental systems and poor oral health literacy of parents and medical professionals alike.

Teamwork in the delivery of pediatric care requires appropriate electronic patient record technology to facilitate sharing of patient information, to avoid patient record discrepancies between systems, and to create efficiencies by maintaining only a single repository for patient demographics. Only comparatively recently have appropriate integrated systems become available to support a range of clinical sites from pediatric special needs clinics to the largest children's hospitals. Nationwide Children's has given practical examples of efficient decision-making in identifying an integrated system to acquire. Much more work will be needed to develop the means to move towards integrating office and community-based care for children through the sharing of electronic health records.

4.2.2 Periodontal Disease and Kidney Disease

Beth Piraino

Oral health is an oft neglected area in the care of patients who have chronic kidney disease. Furthermore, the provision of care by dentists and physicians to the same patient is fragmented as communication between the two health care providers is scant. Emerging data suggesting the periodontal disease is closely linked to chronic kidney disease highlights the importance of proper oral health and the importance of communication between dentists and physicians in the care of the patient.

Investigators used data from NHANES III, including information on 11, 211 adults who had an oral examination by a dentist who categorized each patient as having no periodontal disease, periodontal disease or edentulous to examine the relationship between numerous risk factors for moderate to severe chronic kidney disease, as determined by calculation of estimated GFR through use of the MDRD formula (Fisher et al. 2011). No chronic kidney disease was defined as an estimated GFR of 60 ml per min per 1.73 m^2. Three percent of the patients had CKD, 22.5% were hypertension and 4.4% had diabetes (2.4% with glycated hemoglobin of 7% or higher). Four models were constructed to examine the potential relationship between periodontal disease and CKD. In model one adults with either periodontal disease or edentulous had an adjusted odds ratio of 1.83 (with 95% confidence intervals of 1.31–2.55) of having CKD, independent of the other risk factors for CKD including of age above 60 years, ethnicity, hypertension, smoking status, female gender and C-reactive protein elevation. The fourth model contained 15 potential risk factors including the periodontal disease score and for every 1-unit increase in the score, the risk of having CKD increased by 1% controlling for the other risk factors. The authors hypothesized from their results that the relationship between periodontal disease and CKD was bidirectional in that CKD may increase the risk of periodontal disease which in turn increases the risk of CKD.

Grubbs et al. (2011) also used NHANES data to look more closely at the relationship between periodontal disease and CKD, using dental examinations obtained from 2001 to 2004 (n=6,199 adults, 21–75 years) (Grubbs V, et al. 2011). In this analysis edentulous subjects were excluded and those with albuminuria were included in the definition of CKD. In the entire population CKD was present in 10.6%, but in those with moderate to severe periodontal disease this increased to 21.6%. Other associations with moderate to severe periodontal disease were being older, male, nonwhite, less educated and poor. There was a strong relationship between periodontal disease and CKD (2.5 unadjusted odds ratio). When adjusted for age, gender, tobacco use, hypertension, diabetes, ethnicity, poverty and educational attainment, the odds ratio for the association of periodontal disease and CKD was still significant (1.55). In some groups (Mexican American, poor, and poorly educated) dental care was not received on an annual basis in the majority of this segment of the population.

Periodontal disease has been associated with an increased risk of death in hemodialysis patients (Kshirsagar et al. 2009). This relationship has been poorly studied in peritoneal dialysis patients. This requires further study but it appears possible that periodontal disease might hasten loss of residual kidney function and perhaps contribute to atherosclerosis in dialysis patients and therefore, contribute to the high mortality in this population.

Patients who desire a kidney transplant are required to undergo a thorough evaluation beforehand including an oral examination by a dentist. Some patients on dialysis have inadequate insurance which does not cover dental care, leading to a situation in which a kidney transplant is denied because the patient cannot afford the dental examination.

Communications between dentists and physicians in the care of the patient is scant. If oral surgery is required in a dialysis patient, the surgeon generally requires a brief summary from the nephrologist with recommendations. These might include suggestions for prophylactic antibiotics, avoidance of vasoconstrictor agents to an excess locally (which can elevate blood pressure) and the increased risk of bleeding of a dialysis patient. For more routine dental examinations no information is requested which could potentially lead to drug interactions or a dangerous situation.

Most nephrologists and health care providers in the dialysis unit do not inquire of the patient concerning dental health and examination of the mouth is quite uncommon. Although the dialysis patient is seen monthly at a minimum, there is little conversation or documentation of oral health.

Connecting the electronic health records of in-patient care, the out-patient dialysis unit and the dentists' office could potentially have a large impact in improving the care of those with end stage kidney disease.

4.2.3 What the Provider Needs to Know: Supporting Each Other's Efforts

Wells Shoemaker

Integrating medical and dental records in EHR's may or may not be the "golden ring." First, we need to integrate the clinical thinking…something we both realize is important, but not likely to be solved by an inert computer. I also think that integrated records will be very cumbersome, given the fact that the language used by the separate disciplines is so different, and the kind of detail required to support good decisions and good work is so different. It could be done…but for many professionals on either "side," they would never open the other module. To me, a more sensible solution may be to have a condensed "nugget" of information that could cross populate.

"Moderate periodontal disease" may be what the medical doctor needs to know, plus know what a treatment plan may include. She won't need to know the number of the teeth with the deepest pockets and erosions but will need to support the patient's determination to follow through. On the other hand, if the patient has shown remarkable initiative in gum care and has successfully migrated to a lower severity index, that would be important for congratulation and reinforcement…and also to encourage similar diligence in managing, let's say, the hypertension that is not optimally controlled.

In the other direction, the dentist should know that a patient has been erratic in clinical follow up, does not self-test blood glucose, uses hypoglycemic drugs only intermittently, and has failed several appointments for eye exams. This would lead to a rather different set of approaches from a highly motivated grandmother who is enrolled in a community cultural center's senior exercise club, and is learning to become a lay community teacher for diabetes.

Right now, I don't think even this superficial degree of information is exchanged. We need to support each other's efforts, but we probably do not need to share minute details.

4.2.4 Integrating Ophthalmic Imaging: Seeing the Big Picture in a Small Organ

Jessica Kovarik and Evan Waxman

The benefits of an electronic health record are well described. EHRs allow for legible standardized documentation and easier sharing of patient data between providers at multiple locations. They are less prone to loss and require much less space to store. They have the potential to result in a reduction in the cost of health care.

A distinct disadvantage of the EHR, in its current configuration, is the problem of information overload. Simply put, there is often too much information presented in a way that is difficult to review and digest. The EHR equivalent of thumbing through a chart quickly is not yet available. As a result we frequently see practitioners look only at the last note or two as they review a patient's history.

We require a way to communicate information directly relevant to patient diagnosis, treatment and prognosis among subspecialists and primary care providers. We require a way to identify subclinical cerebrovascular disease in a patient, independent of blood pressure and other traditional risk factors. We require a way to recognize which patients with cerebrovascular disease are two to four times more likely than average to develop a stroke in the next 3 years. We have a way – retinal imaging.

The eye is the one place in the body we can directly observe arteries, veins and a cranial nerve in a noninvasive manner. Routine imaging of the retina and optic nerve could allow primary care providers to assess retinal, and by proxy systemic, end organ damage from atherosclerosis in an efficient manner. The key to optimal use of the medical record and efficient yet effective communication among providers may lie with the familiar adage; a picture is worth a 1,000 words.

Traditionally, when ophthalmologists communicate with primary care providers they send brief letters regarding the findings seen during a yearly dilated examination and the presence, absence or progression of diabetic retinopathy. These letters end by exhorting the virtues of improved blood sugar, blood pressure and lipid control, a sentiment that the primary care provider likely shares. This system of communication does not provide particularly useful information for the primary care provider, except to serve as a notice that the standard of care screening guidelines have been met. The box has been checked.

If primary care providers, cardiologists, nephrologists had access to routine ophthalmic imaging, they would be able to directly visualize the effect that suboptimal blood sugar control is having on their diabetic patients. As importantly, they would be equipped with information directly predictive of congestive heart failure, stroke, and cardiovascular mortality for their patient with hypertension, hyperlipidemia and for those who smoke.

Large clinical studies have shown that assessment of retinal vascular changes such as retinal hemorrhages, microaneurysms and cotton wool spots provides important information for vasculopathy risk stratification. As an example, Wong et al. showed that the presence of retinopathy indicates susceptibility to and onset of preclinical systemic vascular disease, independent of and qualitatively different from measuring blood pressure or lipids (Wong and McIntosh 2005). In the Atherosclerosis Risk in Communities (ARIC) study, individuals with hypertensive retinopathy signs such as cotton wool spots, retinal hemorrhages and microaneurysms were two to four times more likely to develop a stroke within 3 years, even when controlling for the effects of blood pressure, hyperlipidemia, cigarette smoking and other risk factors (Wong et al. 2001). In a recent study by Werther et al., patients with retinal vein occlusions were found to have a two-fold increased risk of stroke compared to controls (Werther et al. 2011).

In addition, the ARIC study group reported that individuals with retinopathy were twice as likely to develop congestive heart failure as individuals without retinopathy, even after controlling for pre-existing risk factors (Wong et al. 2005a).

Interestingly, even among individuals without pre-existing coronary artery disease, diabetes or hypertension, the presence of hypertensive retinopathy was associated with a three-fold increased risk of congestive heart failure events (Wong et al. 2005a). In the Beaver Dam Eye Study, cardiovascular mortality was almost twice as high among individuals with retinal microaneurysms and retinal hemorrhages as those without these signs (Wong et al. 2003a, b). The ARIC and Beaver Dam Eye Studies have also shown that, independent of other risk factors, generalized retinal arteriolar narrowing predicts the incidence of type II diabetes among individuals initially free of the disease (Wong et al. 2002a, 2005b).

A primary care provider with access to patients' retinal photographs may therefore have the evidence needed to suggest which patient with either established systemic vascular disease or preclinical systemic vascular disease requires a more aggressive treatment and risk factor modification. They could do this without wading through the electronic equivalent of piles of records. One photograph could reflect both acute changes in blood pressure (retinal hemorrhages, microaneurysms and cotton wool spots) and chronic changes resulting from cumulative damage from hypertension (AV nicking and generalized arteriolar narrowing) (Sharrett et al. 1999; Wong et al. 2002a; Leung et al. 2004).

In Brown et al. 23 out of 24 patients, excluding those with known diabetes, that presented with a single cotton wool spot or a predominance of cotton wool spots on examination of the retina were found to have underlying systemic disease (Brown et al. 1985). Systemic work-up revealed diagnoses including previously undiagnosed diabetes, hypertension, cardiac valvular disease, severe carotid artery obstruction, leukemia, metastatic carcinoma, systemic lupus erythematosus, AIDS and giant cell arteritis (Brown et al. 1985). These findings illustrate the importance of retinal findings on a systemic level.

The utilization and integration of ophthalmic imaging may serve to achieve more effective communication among subspecialists and primary care providers and ultimately to provide improved diagnosis and treatment for delivery of optimal quality of patient care. Moreover, the improved integration and maximal use of resources may serve to reduce overall health care cost and perhaps decrease provider frustration with the electronic health record (Fig. 4.5).

There are cotton wool spots, exudates, intraretinal dot-blot hemorrhages and microaneurysms. AV nicking is also present especially along the superior arcade just as the vessel leaves the optic nerve (Fig. 4.6).

AV nicking, tortuosity of vessels, intraretinal hemorrhages and dry exudates are seen (Fig. 4.7).

There is edema of the optic nerve head, with cotton wool spots and flame shaped hemorrhage along the disc margin. There are several cotton wool spots along the vascular arcades and scattered dot hemorrhages throughout the posterior pole and periphery (Fig. 4.8).

Notice the cholesterol plaque in the vessel just as it exits the optic nerve head and the pallor in the superior macula corresponding to retinal ischemia and edema (Fig. 4.9).

Fig. 4.5 Nonproliferative diabetic retinopathy and hypertensive retinopathy

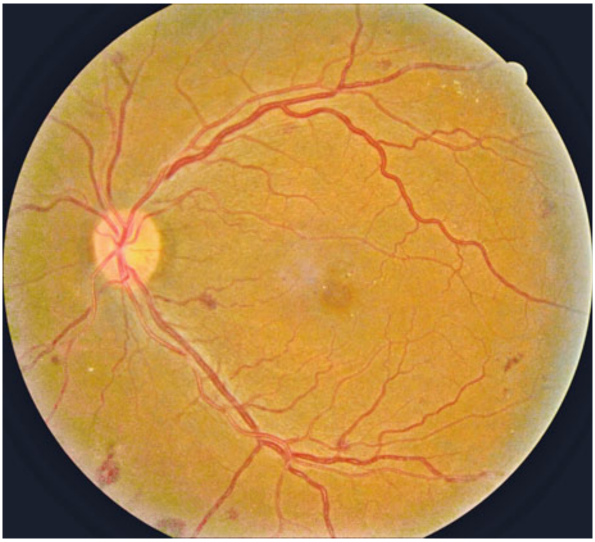

Fig. 4.6 Hypertensive retinopathy

The cholesterol embolus has resulted in lack of blood flow to the superior arcade (Fig. 4.10).

There is pooling of subretinal blood just superior to the optic disc with a central fibrin clot and associated vitreous hemorrhage (Fig. 4.11).

Optic disc edema, flame hemorrhages and venous congestion are seen in a patient with severe hypertension.

Fig. 4.7 Central retinal vein occlusion

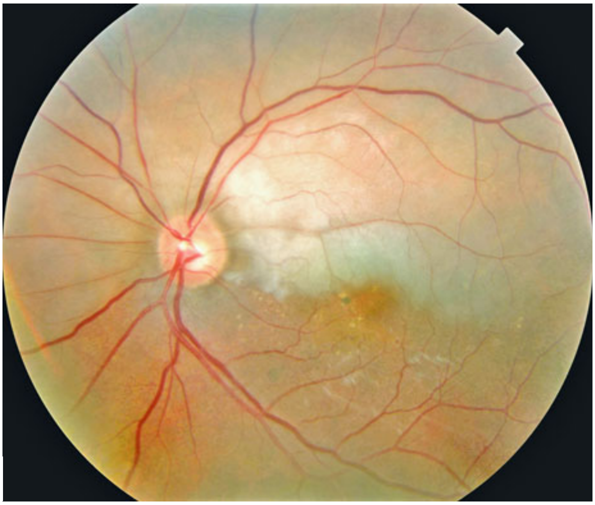

Fig. 4.8 Branch retinal artery occlusion

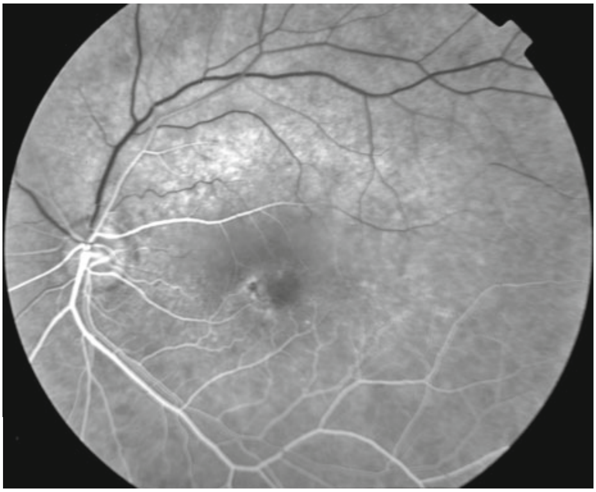

Fig. 4.9 Branch retinal artery occlusion, fluorescein angiogram

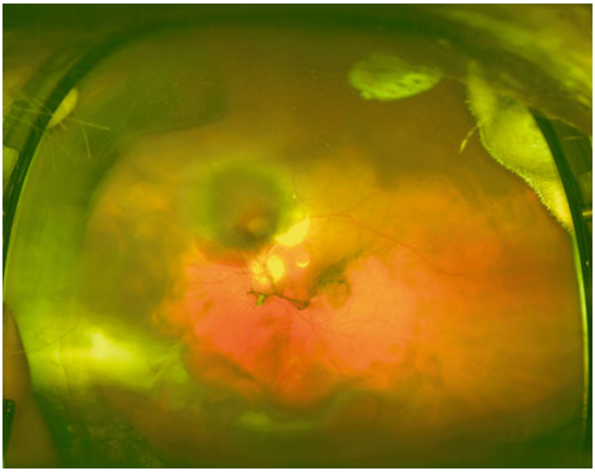

Fig. 4.10 Retinal macroaneurysm

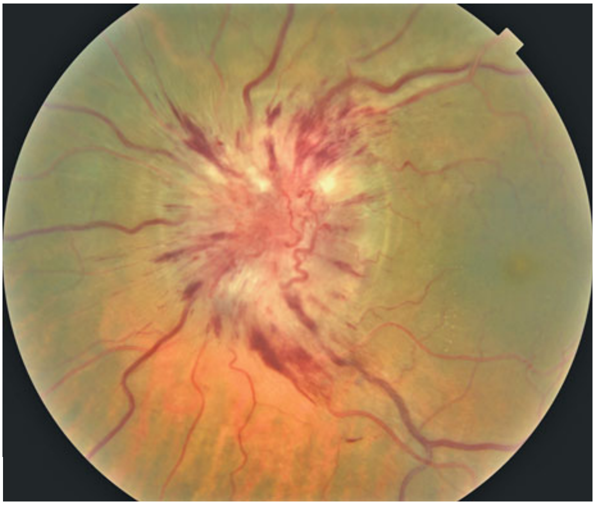

Fig. 4.11 Hypertensive optic neuropathy

4.2.5 Do Dentists and Otolaryngologists Need to Collaborate? If So Does Their Patient Record System Help Them Do It?

Biju Cheriyan

In clinical practice, an otolaryngologist often needs a dental consult not only because of the topographically adjacent nature of the structures but also because most structures are supplied by the same neurovascular bundle and therefore there is overlapping of symptoms. The converse scenario can also apply. Apart from this, there are many systemic medical conditions (for example: bleeding diatheses, diabetes) a dentist encounters throughout his or her practice which can determine the outcome of a successful treatment. Sometimes, providers may observe a cluster of diagnostic criteria which may have to a single source. In the sections below, I will explore a few of these scenarios and conditions, and indicate where and how an integrated electronic health record (EHR) could optimize delivery of health care by dentists and otolaryngologists.

4.2.5.1 Congenital Conditions

Cleft palate/Cleft lip: Cleft lip and cleft palate (CL/CP) are congenital conditions that require multidisciplinary management by dentists, oral and maxillofacial surgeons, orthodontists, otolaryngologists, speech pathologists and plastic surgeons A number of studies report that a multidisciplinary approach is essential for better treatment outcomes (Wangsrimongkol and Jansawang 2010) and for post operative rehabilitation (Furr et al. 2011). These multidisciplinary approaches may lead to new ways to manage and treat CL/CP patients (Salyer et al. 2009).

Hutchinson's teeth: Notching of the upper two incisors is typically seen in individuals inflicted with congenital syphilis.

Macroglossia refers to enlarged tongue in relation to oral cavity. Macroglossia is an important sign. It can indicate important systemic diseases like systemic amyloidosis, congenital hypothyroidism, acromegaly, or Down syndrome.

4.2.5.2 Headache

A common complaint that dentists and otolaryngologists encounter in their practice is the common headache. Because of the special nature of the neurovascular bundle of the head and neck this symptom can be presented to both dentists and otolaryngologists (Ram et al. 2009). Any sinus pathology can present as a headache to an otolaryngology practice. Since the maxillary sinus floor is in close proximity to the maxillary premolars and molars, it is imperative to obtain a dental evaluation in persistent cases of headache. There are a number of causes for headache from the dental and otolaryngology perspective. A mal-aligned denture patient with chronic headache, whom I saw in my practice was shuttled between departments and an array of investigations only to find at the end that an ill-fitting denture caused the intractable headache. In these cases, an integration of findings is extremely important in providing quality treatment to the patient and also saves money and time for the whole health care system. Hence it is important to have an integrated patient record for this particular symptom alone.

4.2.5.3 Trigeminal Neuralgia

Trigeminal neuralgia is facial pain of neurogenic origin experienced along the distribution of the trigeminal nerve(fifth cranial nerve). It can present as a dental pain and can also be triggered by brushing teeth among other trigger factors. As a result, patients with dental pain without obvious causes are required to have a physicians' consultation to rule out this obscure condition. Sometimes it is diagnosed by omission (Aggarwal et al. 2011; Rodriguez-Lozano et al. 2010; Spencer et al. 2008).

4.2.5.4 Tumors of Nasal Sinuses

Any tumor of the nasal sinuses (specifically maxillary and ethmoids) can erode the lower bony wall and present in the oral cavity (usually the maxillary arch) as dental pain, loose tooth, etc. Therefore, these are areas of interest to both dentists and otolaryngologists. Such tumors most commonly present first to a dentist or could also be an accidental finding. Cancers of the naso/oro/laryngo pharynx can also present as toothache to a dentist as these structures have a common nerve supply from cranial nerves 5,7 and 9. Therefore, an integration of the patient record may even help in early diagnosis of the tumor. The same principle applies to all oral tumors, tumors of the nasopharynx, the oropharynx etc. This is especially true of malignant lesions of the oral cavity as these may help in early detection and treatment of cancer. In these cases, an early biopsy and histopathology can save the life of the patient. Therefore, it is imperative to say that a collaborative patient record can save patients' lives.

4.2.5.5 Ulcers of the Oral Cavity

Ulcers of the oral cavity from aphthous ulcers to carcinomas can present both to a dentist and an otolaryngologist. Oral ulcers can be of dental origin. Contact ulcers from sharp edges of a mal-aligned tooth can result in intractable ulcers, where a simple smoothing of sharp edges may eradicate the ulcer and terminate it as a chronic condition and can even prevent the ulcer turning into a malignancy. If you have an integrated electronic health record (EHR) these problems are immediately addressed and managed. Otherwise, the condition will consume valuable time of both the patient and the physician concerned. In addition to this, there are a few conditions which require special attention: aphthous stomatitis (canker sore), which may indicate oral manifestation of deficiencies of iron, vitamin B12, folate deficiency and oral candidiasis, which can be a sign of diabetes mellitus or of an immunocompromised patient (e.g. AIDS).

4.2.5.6 Temporomandibular Joint Disorders

Temperomandibular joint (TMJ) disorders can present in a variety of symptoms to both dentists and otolaryngologists. They can present as a headache, earache, toothache, or as facial pain. There can be a number of causes for this including osteoarthritis of the TMJ, recurrent dislocation, bruxism, or even an ill fitting denture. There have been cases where patients have been subjected to removal of teeth for chronic toothache only to discover at the end that the symptom was a referred pain from TMJ! Therefore, an integrated EHR can prevent misdiagnoses and resulting impairment or disability to patients. Trismus (lock jaw) can indicate important diagnoses such as tetanus and rabies.It is due to a spasm of muscles of mastication, which is an important oral manifestation of widespread muscle spasm. Apart from these conditions, other causes of trismus are peritonsillar abscesses, and scleroderma.

Other problems dentists and otolaryngologists encounter in clinical practice are concurrent systemic diseases (patients with multiple problems): patients with bleeding diatheses, diabetes mellitus and a hidden primary malignancy. A non-healing ulcer in the oral cavity may hide a primary malignancy behind it. In these cases, you have to look for it specifically. Similarly, one has to be aware of oral manifestations of internal pathology. Some of them are Crohn's disease, ulcerative colitis and gastro-intestinal tract malignancies.

Often dentists see patients after a tooth extraction with intractable bleeding to find that they have a bleeding diathesis. So, this may be the first presentation of these patients' bleeding disorder. When this patient undergoes any elective procedure in future, it will be a great help to surgeons to be aware of this information to prevent any inadvertent complications. Therefore an integrated EHR can prevent unwanted complications where a patient's life may be in jeopardy.

4.2.5.7 Refered Otalgia (Earache)

The source of otalgia or earache can be from a number of sites other than ear itself. Technically ear lobe and ear canal are supplied by four different cranial nerve branches (5th, 7th, 9th, 10th). Therefore, an area with a common nerve supply can present as earache. Common dental problems which present as referred otalgia are (1) dental caries (2) oro-dental diseases or abscesses (3) an impacted molar tooth (which is a common cause) (4) malocclusion (5) benign and malignant lesions of oral cavity and tongue (Kim et al. 2007). Therefore, it is essential these two departments collaborate with each other in diagnosing and treating these diseases, and one way of facilitating it is through an integrated EHR system.

4.2.5.8 Halitosis (Bad Breath)

There is a lot of overlap between dentists and otolaryngologists in the diagnosis and treatment of patients with halitosis (Delanghe et al. 1999; Bollen et al. 1999). Poor oral hygiene is the most common cause for this common complaint. Oral causes include tooth caries, oral ulcers, periodontal diseases, unhealthy mucosa of the oral cavity. It is interesting to note that a simple oral ulcer can form an abcess eroding the floor of mouth and becoming a life-threatening oral cellulitis (Ludwig angina). Once the cellulitis has developed, it becomes a medical emergency. Therefore, it is essential to prevent it before it can progress into a life-threatening condition, which of course is possible. Causes pertaining to otolaryngologists include: chronic sinusitis or mucociliary disorder, chronic laryngitis or pharyngitis, pharyngeal pouches-related pathology, tumors or ulcers of naso/oro/laryngopharynx, diseases or conditions that impair normal flow of saliva such as salivary gland diseases or stones preventing flow of saliva, medications which cause dryness of mouth: antihistamines, antidepressants; local manifestation of systemic disorders: auto immune disorders, Sjögren syndrome, dehydration from any cause, diabetes mellitus and Gastro Esophageal Reflux Disorder (GERD).

GERD is caused by improper neuro-autonomy of the lower esophageal sphincter (LES). The LES does not close tightly after food intake which causes gastric content to enter the esophagus. Over time this can erode mucosa and cause various diseases even becoming cancerous (Friedenberg et al. 2010). This disorder is attributed to life style. Fast food consumption habits (oily fried foods) and eating habits (swallowing food without properly chewing) are partly responsible for this disorder (Lukic et al. 2010; Al-Humayed et al. 2010). Here again an early diagnosis can manage the disease process before it is fully developed.

At present there are no integrated EHR systems serving these specialties (dentistry and otolaryngology). An integrated EHR would facilitate efficient communication between a dentist and an otolaryngologist who are providing care to the same patient and addressing a problem with a shared focus between the two disciplines. Such integrated communication, may only require consulting the available medical or dental record of the patient, based on the particular circumstance. Even enabling this simple communication would avoid duplication of effort, clarify the context of certain symptoms and reduce stress endured by the patient. It also has the potential to reduce healthcare delivery costs, and in some cases, even contribute to saving the patient's life.

4.2.6 Providing Collaborative, Interdisciplinary Healthcare to Patients with Neurodevelopmental Disorders and Intellectual Disabilities

Henry Hood, Allan G. Farman, and Matthew Holder

In this chapter, the authors attempt to put forth a justification for precisely this kind of collaborative approach through a summary and discussion of a series of actual clinical cases. The protocols discussed in the management of each of these clinical cases illustrate the value in providing whole-person, interdisciplinary health care to this complex patient population.

4.2.6.1 Surveying the Landscape

There is arguably no single patient population for whom the provision of collaborative, interdisciplinary health care is more challenging than for patients with neurodevelopmental disorders and intellectual disabilities (ND/ID). In planning and delivering the generally-accepted standard of health care to this unique population, myriad biomedical, psychosocial and sociopolitical realities converge to create a landscape that is, at best, daunting for patients with these disorders, and for the clinicians who are charged with their care.

Anecdotal and scientific evidence suggest that this landscape has produced a paucity of physicians and dentists who are willing and able to provide care to patients with ND/ID, and that American medical and dental schools are providing little training focused on their care (Holder et al. 2009; Wolff et al. 2004).

In February of 2002, 16th Surgeon General David Satcher issued a report, which documented that Americans with ND/ID experience great difficulty accessing quality health care (Thompson 2002). In that same report, former Health and Human Services Secretary Tommy Thompson said, “Americans with mental retardation and their families face enormous obstacles in seeking the kind of basic health care that many of us take for granted.” (Thompson 2002) The disparities identified by Dr. Satcher and Secretary Thompson require that physicians and dentists approach this population in a spirit of collaboration, compassion, and teamwork in order to produce positive health outcomes for them.

Perhaps, an even greater imperative driving the need for collaboration between medicine and dentistry in this arena is the fact that many patients with intellectual disabilities have developed this cognitive impairment as the result of an underlying neurodevelopmental disorder that is often undiagnosed. And it is this neurodevelopmental illness and the constellation of potentially devastating complications associated with that illness that create a biomedical fragility and a vulnerability that neither begins nor ends at the oral cavity, and that leaves these patients at risk in almost every aspect of their daily lives.

When, for example, patients with ND/ID are dependent upon publicly-funded programs for their health care, and when these systems fail to provide the health services that biomedically complex cases require because they fail to account for and accommodate the link between medical and dental pathologies, the risk of a negative outcome is greatly enhanced. Such was the case for an intellectually disabled woman in Michigan who, in October of 2010, was unable to access dental services through the state’s public medical assistance program, and who fatally succumbed to a systemic bacteremia resulting from an untreated periodontal disease (Mich. Dent. Assoc. 2009).

4.2.6.2 Neurodevelopmental Disorders and Their Associated Primary Complications

The American Academy of Developmental Medicine and Dentistry (AADMD) defines a neurodevelopmental disorder as a disorder involving injury to the brain that occurs at some point between the time of conception and neurological maturation – approximately age 21 or 22 (Zelenski et al. 2008).

Examples of frequently-encountered neurodevelopmental disorders would include Fragile X syndrome, a genetically acquired neurodevelopmental disorder caused by a mutation at the distal end of the long arm of the X chromosome

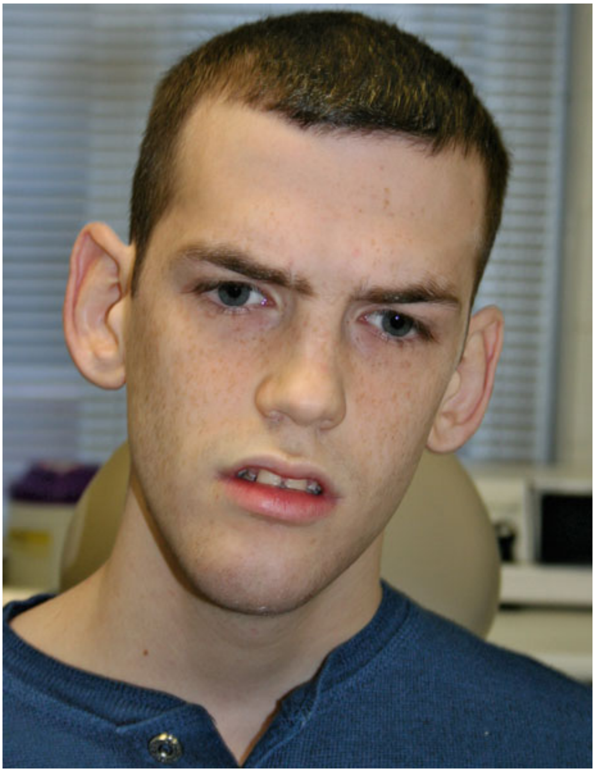

Fig. 4.12 Fragile X syndrome

(see Fig. 4.12), Trisomy 21, another genetic disorder, which features extra genetic material at the chromosome 21 site (see Fig. 4.13), and Cerebral Palsy, a prenatal or perinatal, acquired neurodevelopmental disorder (see Fig. 4.14).

Patients with neurodevelopmental disorders tend to present clinically with one or more of five frequently-encountered, objective symptom complexes or primary complications. These five, classic primary complications include intellectual disability (aka: mental retardation), neuromotor impairment, seizure disorders, behavioral disturbances, and sensory impairment (AADMD).

Additionally, multiple secondary health consequences can derive from the five primary complications; and any one of these secondary health consequences, or a combination of them, can produce profound morbidity. An example of a common secondary health consequence seen in patients with ND/ID, which is derived from intellectual disability and / or neuromotor impairment, is the patient who is unable to care for his or her own mouth, and who develops ubiquitous caries and advanced periodontal disease as a result (See: Fig. 4.15). Another example would be the patient who suffers from the secondary health consequence of gastroesophageal reflux disease (GERD) as a result of the neuromotor impairment associated with multiple neurodevelopmental disorders; and whose tooth enamel and dentinal tissues become chemically eroded as a result of the chronic intraoral acidity produced by GERD (See: Fig. 4.16).

Fig. 4.13 Trisomy 21

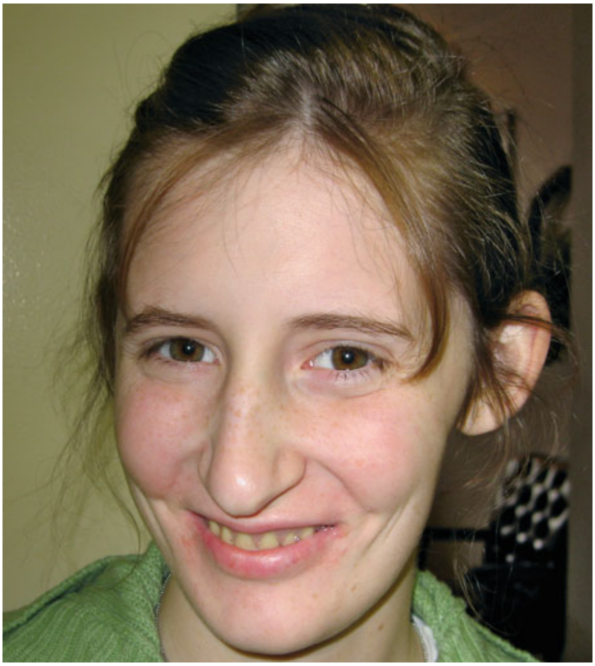

Fig. 4.14 Cerebral palsy

Fig. 4.15 Patient with congenital syphilis

Fig. 4.16 GERD-related erosion of enamel and dentinal tissues

Fig. 4.17 Patient on phenytoin

The diagnosis and management of these secondary health consequences provide dentists and physicians with a unique opportunity to work together to improve the quality of health and quality of life for their patients by implementing a team approach, which crosses the traditional interdisciplinary lines of communication, and which expands each clinician's ability to make meaningful treatment options available. Indeed, it is often the case that quality primary care provided in one discipline will provide potentially valuable information to an attending clinician from another discipline. Such is the case with the patients featured in Figs. 4.16 and 4.17.

4.2.6.3 The Adult Patient with ND/ID and Undiagnosed Syphilis

The patient whose intraoral photograph is featured in Fig. 4.14 is a 19 year-old male patient who presented to a special needs dental clinic accompanied by his mother. The mother indicated that her son was exhibiting hand-mouthing behaviors that she believed suggested he was experiencing mouth pain. A comprehensive radiographic and intraoral exam revealed, among other maladies, notched incisors, multiple diastemas, grossly decayed mulberry molars, and advanced periodontal disease. The patient also exhibited moderate to severe intellectual disability.

These findings were all consistent with a diagnosis of congenital syphilis.[6] However, in developing the medical history with the mother, it was learned that no previous diagnosis of syphilis had been discussed with the mother, nor was it included in the health history.

In cases like this, a comprehensive dental treatment plan should always include consultation with the primary care physician for purposes of moving forward with confirmation of the clinical diagnosis by serologic testing, and consultation with a cardiologist to assist in the management of potential cardiovascular sequelae.

As the dental treatment plan is being developed, consideration should also be given to Human Immunodeficiency Virus (HIV) testing for this patient, as coinfection is a common finding[7]. This issue could easily be attended to by a primary care physician, an internist or an infectious disease specialist. In the absence of any of these team members, the dentist should feel entirely comfortable ordering HIV testing.

The primary care physician and the developmental dentist should continue to advise each other and their respective consultant specialists of any significant developments or new information, which could in any way impact either the medical or the dental treatment plan. As treatment progresses, both the physician and the dentist should expect improvement in the patient's periodontal status, which will likely be reflected in a decrease in the frequency of immune-related illnesses, and in the maladaptive behaviors produced by chronic oral pain.

It is quite often the case in this patient population that, with a reduction in maladaptive behaviors, comes a reduction of the use of psychotropic medications prescribed in a frequently futile attempt to manage behaviors that were born of an undiagnosed medical or dental illness.

4.2.6.4 The Adult Patient with ND/ID and Undiagnosed GERD

GERD is defined as the reflux of gastric contents into the esophagus. GERD is primarily associated with incompetence of the lower esophageal sphincter; however there are numerous co-contributors, which may predispose a patient to GERD or exacerbate an existing reflux problem. These co-contributors include a diet high in fat, neuromotor impairment associated with functional abnormalities such as dysphagia, neuromotor impairment associated with impaired ambulation and prolonged periods of recumbence, and the use of multiple medications including anxiolytics, calcium channel blockers, and anticholinergics. GERD is thought to affect approximately 25–35% of the general US population.

It has been established in the literature that the incidence of GERD in patients with intellectual disabilities is significantly higher than in the neurotypical population, and that the relative number of unreported cases of GERD is much higher in patients with a neurodevelopmental diagnosis, as well.

Patients who have gastric reflux as a function of a neurodevelopmentally-derived neuromotor impairment and a coexisting intellectual disability are impaired in their ability to voice the complaint that would, in the neurotypical patient, commonly lead to an encounter with either a family physician or a gastroenterologist and, ultimately, to a diagnosis. This inability to voice a complaint can be problematic in that, left untreated, GERD can produce maladaptive and sometimes aggressive behaviors in this population. And, of even greater concern, is the fact that undiagnosed esophageal reflux can lead to more complex conditions that can produce significant morbidity or even mortality – maladies such as Barrett's esophagus or adenocarcinoma of the esophagus.

Chronic GERD can also produce an acidic intraoral environment, which can lead to the chemical erosion of the enamel and dentinal tissues of the teeth. Ali et al. have established a link between erosion of the enamel and dentinal tissues of the teeth and GERD. There is additional anecdotal evidence suggesting a link between tooth enamel erosion and GERD, and related maladies. A special needs dental clinic in the eastern United States serving 1,000 patients with ND/ID, has reported that, of nine patients referred to gastroenterology who presented for dental exam with a finding of either tooth enamel erosion or ubiquitous caries, two cases were diagnosed with GERD, two with Barrett's esophagus, three with gastritis, and one with duodenitis. In all cases, medical treatment was required.

In light of all that is known about the incidence of GERD and of the GERD-related risks unique to this patient population; and in light of the link between tooth enamel erosion and GERD, it is incumbent upon any dentist encountering tooth enamel erosion in a patient with an intellectual disability to immediately refer that patient to gastroenterology for a work up, which should include esophagogastroduodenoscopy (EGD) and pH monitoring.

A dentist encountering GERD in a patient with an intellectual disability must be aware that he or she may be the first and only link between that patient and the diagnosis of a potentially life-threatening illness.

4.2.6.5 The Adult Patient with ND/ID and Phenytoin-Induced Gingival Enlargement

Phenytoin-induced gingival enlargement can appear as either an inflammatory lesion or a more dense, fibrotic hyperplastic lesion. The inflammatory lesion is one in which the gingival tissues are swollen and bleeding, and in which pain is often a component. This type of gingival enlargement is the more acute lesion, frequently seen in patients who are currently taking Phenytoin. In advanced cases of inflammatory gingival enlargement, the tissues can appear botryoid, with a characteristic grape-cluster appearance. In advanced cases of Phenytoin-induced gingival enlargement, the lesion can sometimes shroud entire sections of the dentition.

Phenytoin has long been a common medication used to treat seizure disorders in patients with neurodevelopmental disorders and intellectual disabilities. However, the gingival enlargement it produces, and the obstacle this lesion can pose to effective oral hygiene – especially in a population in which oral hygiene is typically compromised – can, over time, lead to periodontal disease, edentulism, and in advanced cases, systemic bacteremias. Gingivectomy performed to reduce Phenytoin-induced gingival enlargement will typically fail unless the patient is weaned off the offending medication, and another anti-seizure medication is titrated to effect. Multiple alternative anti-seizure medications are currently available, which do not have the side effect profile of Phenytoin, and most patients who are weaned off Phenytoin will demonstrate a virtual 100% resolution of the inflammatory lesion within a matter of 3 or 4 months.

The image in Fig. 4.18 is of a 22 year-old, microcephalic African-American male with intellectual disability, neuromotor impairment, and a seizure disorder. Figure 4.17 illustrates the appearance of this patient's gingival tissues while he was currently on Phenytoin. Figure 4.18 features the same patient 4 months after being weaned off Phenytoin and placed on Topiramate.

Fig. 4.18 Patient 4 months post-weaning

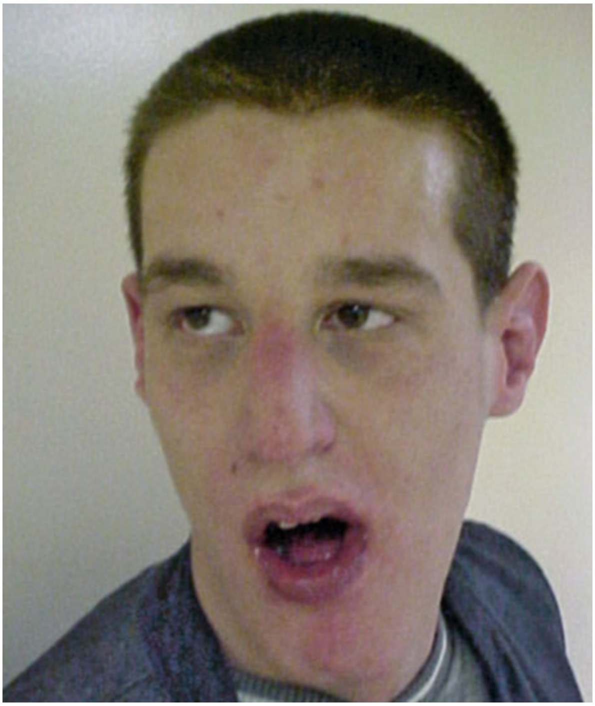

Fig. 4.19 The adult patient suspected of having Fragile X syndrome

These images illustrate the dramatic result that can be achieved when a dentist and a physician work in collaboration in the best interests of the patient. It is worth noting that this particular collaboration required only one intervention to achieve this result: The patient was weaned off Phenytoin and was placed on a safer alternate anti-seizure medication.

Any dentist caring for a patient with an intellectual disability who presents with Phenytoin induced gingival enlargement should immediately contact either the primary care physician or neurologist managing the patient's seizure disorder, and strongly urge that the patient be weaned off Phenytoin and placed on a safer alternative anti-seizure medication. Edentulism and bacteremia need not be a side-effect of a seizure management protocol.

The patient seen in Fig. 4.19 is a 20 year old male patient with idiopathic intellectual disability who presented to an outpatient dental clinic for comprehensive dental evaluation and treatment. He was accompanied by his father. His father was referred to the clinic by the staff at his son's day program workshop. The day program staff had observed hand-mouthing behaviors, and they had voiced concern that the patient may be in pain.

In the waiting room, the patient exhibited behaviors consistent with neurodevelopmental dysfunction. He was non-communicative, and his gaze aversion and tactile defensiveness were suggestive of autism. He was resistant and somewhat combative when directed to the dental chair, and effective behavior management in both the waiting room and operatory required the combined efforts of his father and two staff

Fig. 4.20 Pectus excavatum

members. The patient's health history was positive for attention deficit hyperactivity disorder (ADHD), and there was no history of seizure or neuromotor impairment.

The father indicated that, at age ten, the patient was admitted to an inpatient psychiatric unit for evaluation of his uncontrollable behavior. The following day, the parents were told that managing the patient's behavior was beyond the ability of the psychiatric unit staff, and the parents were asked to take the child home. The father also indicated that the psychiatric unit staff described the child's behavior as overwhelming.

The patient was last seen by a dentist 12 years prior to presentation; examination and treatment at that time were carried out in the operating room under general anesthesia.

Effective oral examination of this patient required utilization of papoose board and Molt mouth prop. Multiple options for behavior management, including utilization of general anesthesia in the operating room, were discussed with the father, and informed consent to utilize medical immobilization techniques for purposes of this examination was obtained and documented prior to taking the patient into the operatory. In the operatory a dental examination was performed, and a baseline panel of digital radiographs was obtained.

The head and facial features of this patient were suggestive of Fragile X syndrome (See: Fig. 4.20). The body of the mandible was somewhat elongated; the

Fig. 4.21 Joint laxity observed in patient with Fragile X syndrome

Fig. 4.22 Four children with autism and one neurotypical child

nose was prominent; the head had somewhat of a triangular shape, and the patient readily averted his gaze. Upon further inquiry, the father reported that the patient also exhibited macroorchidism, although he indicated that no physician or dentist had ever suggested a work up for Fragile X.

Fragile X syndrome is a disorder with which many clinicians are unfamiliar. Yet it is the second leading genetic cause of intellectual disability in the United States, and it is the leading known cause of autism in the U.S. In addition to the phenotypic findings noted in this case, there are other frequently-encountered physical characteristics consistent with Fragile X that may move a clinician toward this diagnosis. They include pectus excavatum or funnel chest (see Fig. 4.21) and joint laxity (see Fig. 4.22).

Gaze aversion, as previously mentioned, is a typical finding in autism and in Fragile X syndrome. Indeed, in conjunction with non-verbal behaviors, gaze aversion is often the finding that initially alerts the clinician to the possibility of a neurodevelopmental diagnosis featuring autism as a complication. Figure 4.22 features a photograph of five children at a school for children with special needs. Four of the children have been diagnosed with autism, and a fifth child is a neurotypical child who was visiting his brother on the day the photograph was taken. The reader is left to decide which child is the neurotypical child.

Any physician or dentist who encounters a patient with an obvious intellectual disability, who does not have an established underlying neurodevelopmental diagnosis, and who presents with additional findings, which may include gaze aversion, shyness, a prominent chin, pectus excavatum, a large nose or large ears, should suspect a possible Fragile X diagnosis.

The primary care clinician – physician or dentist – should discuss with the guardian or family member the importance of establishing a neurodevelopmental diagnosis. The family member or guardian should be informed that genetic counseling should be made available to all members of the extended family, since Fragile X syndrome is a genetic disorder that can be passed from parents to offspring. Once this discussion has taken place, a referral to a geneticist for a complete genetic work up is indicated. Both the dentist and physician should feel entirely comfortable making this referral. In remote areas where the services of a geneticist may not be available, the attending physician or dentist may order a high resolution chromosomal analysis and a Fragile X DNA test, and have those results sent to a remote location for interpretation by a geneticist. Consultation with a psychiatrist or a clinical psychologist may also be advisable, as patients with Fragile X can sometimes experience enhanced social integration as a benefit of behavioral therapy.

4.2.6.6 Interdisciplinary Solutions for Interdisciplinary Problems

The healthcare access problem for Americans with neurodevelopmental disorders and intellectual disabilities is, at its core, a healthcare education problem – an education problem resulting from a long-standing deficiency in professional training focused on the care of this patient population. And it is clear that the medical and dental professions share equally in responsibility for these deficiencies.

Eighty-one percent of America’s medical students will graduate without ever having rendered clinical care to a single patient with a neurodevelopmental disorder or intellectual disability; and the graduates of 90% of America’s medical residency programs will graduate from those residencies having had no formal training whatsoever – didactic or clinical – in the care of this patient population.[1] Additionally, 50% of graduating dentists have never treated a single patient with a disability.[2]

It is no wonder that patients like those whose cases were discussed in earlier sections of this chapter have such difficulty accessing quality health care. As Robert Uchin, Dean of Nova Southeastern University College of Dental Medicine observed in a speech in 2003 to his faculty, “Not only do we not have enough doctors to care for these patients; we don't have enough teachers to teach them how to care for them."

As a result of these deficiencies in professional education, few clinicians with any expertise in developmental medicine or developmental dentistry are to be found in communities across America. The experts in developmental medicine and dentistry, for the most part, tend to be physicians and dentists who work at the few remaining intermediate care facilities, and at special needs outpatient clinics, psychiatric hospitals, and nursing homes. These physicians and dentists possess the knowledge and expertise in these disciplines because they are the physicians and dentists with the clinical experience. Unfortunately for the patients with neurodevelopmental disorders who are clamoring for quality care, there are too few of these clinicians.

National experts in developmental medicine and dentistry, however, have begun to collaborate in the creation of patient care protocols; and they have produced multidisciplinary curricula in both DVD and online format.

The AADMD has made available 9 hours of online curriculum in developmental medicine, developmental dentistry, and developmental psychiatry (See: List of URLs). The curriculum program is entitled, *The Continuum of Quality Care*, and it teaches collaborative patient care in three disciplines through an interdisciplinary format.

The AADMD, through a grant from the Wal Mart Foundation and the North Carolina Developmental Disabilities Council, and in collaboration with the North Carolina Mountain Area Health Education Center and the Family Medicine Education Consortium, has also established the National Curriculum Initiative in Developmental Medicine. This initiative, which is scheduled for completion in 2012, will develop curriculum standards for physicians in the primary care of adults with ND/ID. The curriculum stresses the importance of a collaborative approach, which includes medicine, dentistry, podiatry, optometry, and multiple ancillary health professions.

If the disparities in access to healthcare for Americans with ND/ID are to be resolved, physicians and dentists must be willing to cross professional boundaries and work together to plan and deliver whole-person healthcare to their patients with ND/ID. Interdisciplinary protocols in the diagnosis of neurodevelopmental disorders and in the management of the secondary health consequences associated with these disorders must be established. Additionally, clinicians with expertise in these arenas must be willing to work and teach in our nation's medical and dental schools. The clinicians with expertise must be willing to develop predoctoral and postdoctoral curricula, and the deans of America's professional schools must be willing to include these curricula as part of their larger programs in primary and specialized care.

The clinicians with expertise in developmental medicine and dentistry must also be willing to conduct patient-focused, interdisciplinary, clinical research in an effort to solve the myriad problems that create obstacles to the delivery of the standard of care for patients with ND/ID. They must be willing to obtain Institutional Review Board approval for this research, and they must be willing to make this research available to their colleagues through publication in peer-reviewed journals and text books, and in professional lecture forums.

The patient featured in Figs. 4.23 and 4.24 is a man named James. He is a 48 year old patient with idiopathic intellectual disability who presented to a dental clinic for

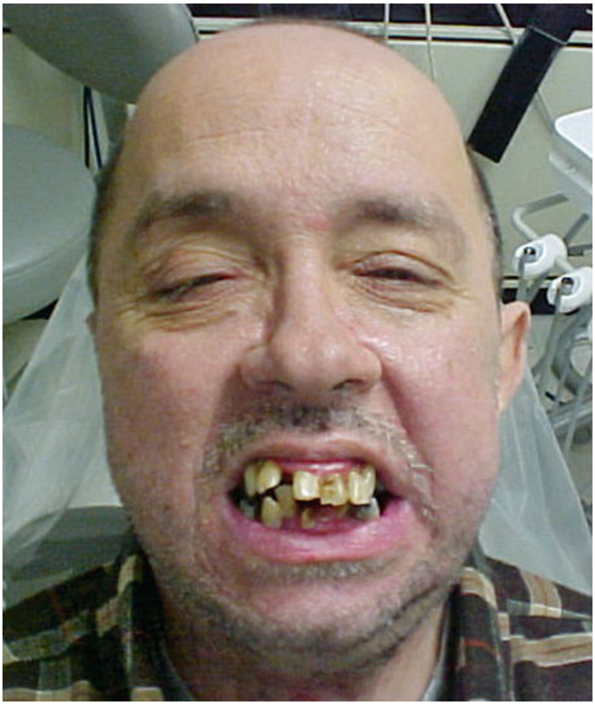

Fig. 4.23 Patient upon initial examination

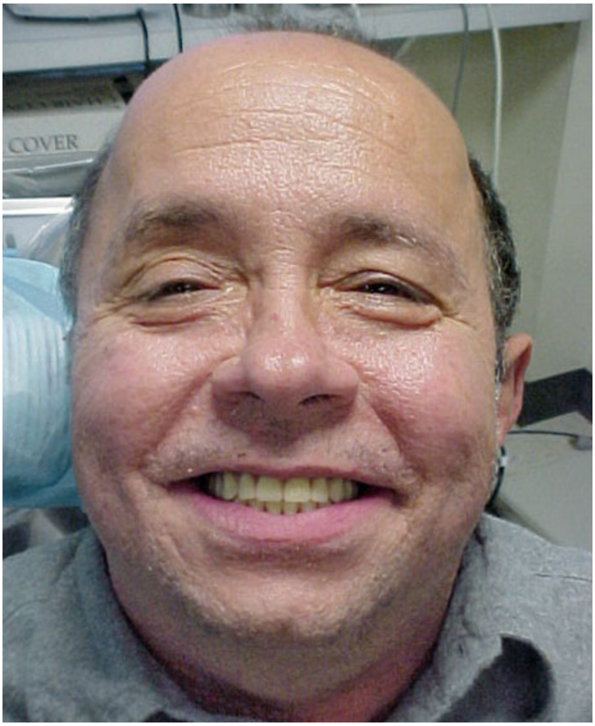

Fig. 4.24 Patient after comprehensive treatment

evaluation of a painful facial swelling. A comprehensive intraoral exam revealed a cellulitis resulting from multiple grossly decayed teeth, and a generalized advanced periodontitis. No fewer than five clinicians became involved in this patient's care. They included a general dentist, two oral surgeons, a family practice physician, and a geneticist.

Over the course of several months, as the treatment plan was completed, and as the chronic dental and periodontal infections were eliminated, James experienced significant improvement in his overall state of health. A comparison of these two photographs reveals not only significant improvement in his aesthetic appearance, but also in his skin turgor and color.

These improvements in the patient's health translated to improvements in his daily life. He found gainful employment, and his caregivers now report that he smiles constantly – at work and at home.

These photographs were entered into evidence in 2007 before a Congressional subcommittee investigating the death of a young African-American boy who died as a result of an untreated dental abscess. The photographs were intended to make the point that patients with intellectual disabilities need not die as a result of medical illnesses derived from untreated dental disease.

This patient's case illustrates that, when physicians and dentists are willing to work together toward a common goal of whole-person health for their patients, profoundly positive outcomes can be achieved.

In a larger context, if our nation's medical and dental professions are willing to commit to a shared agenda, one which promotes the idea of collaborative, interdisciplinary care as a foundational concept, significant improvements in quality of health and quality of life can be realized, not just for Americans with neurodevelopmental disorders, but for every patient seeking quality care.

4.3 Biosurveillance and Dentistry

Miguel Humberto Torres-Urquidy

In light of the events of 2001, bioterrorism has become subject of increased attention from all members of society. Government agencies, professional associations, academia, etc. have expressed their determination to wage war on such threats by all means available. Dentists can also participate in this effort by providing assistance at interested groups and the general public (Flores et al. 2003). In this chapter we will examine the elements and components that may play a role in the establishment of an electronic network for the dental profession for supporting the fight against bioterrorism. In this section we review the threats, the public health system, current electronic surveillance systems, regulations and ethical issues, the computerization of dentistry, and how dentistry can serve in improving biosurveillance efforts.

4.3.1 Background

The aftermath of September 11 and the anthrax incidents in October 2001 (Lane and Fauci 2003), made the US government reorganize its priorities and reform its current structure (White House Office of the Press Secretary 2003). In response to these incidents, President Bush proposed the "Health Security Initiative" (White House Letter 2002) in February 2nd of 2003. This effort labeled the "Bioshield Initiative," (White House Letter 2002) has the purpose to stimulate research and development of medical countermeasures against bioterrorism attacks. However, despite all these efforts, terrorist attacks are likely to happen in the future and even the best work from intelligence and security agencies will be unable to prevent such events (Betts and Richard 2002; Council on Foreign Relations 2003; Baker and Koplan 2002). To cope with this threat, a report published by an independent task force sponsored by the Council on Foreign Relations "America-Still Unprepared, Still in Danger" (Council on Foreign Relations 2003), suggested a series of steps to assist the government in preparing to better protect the country. One of these suggestions is the bolstering of the "Public Health Systems".

4.3.2 Public Health Systems

Baker et al. define the U.S. public health system as a system that consists of a broad range of organizations and partnerships needed to carry out the essential public health services, such as hospitals, voluntary health organizations, other non-governmental organizations and the business community (Baker and Koplan 2002) which can collaborate with local, state and federal public health entities. After the unfortunate incidents in 2001 the public health system was revisited and the realization that "the nation's public health infrastructure is not fully prepared to meet this growing challenge" (Frist 2002) became clear. To address this need, Congress and President Bush enacted the Public Law (P.L.) 107–188 titled "Public Health Security and Bioterrorism Preparedness and Response Act of 2002" (Frist 2002; 107th Congress 2002). The main purpose of this law was to improve the public health capacity by means of increasing funding and fostering other measures. Frist (2002), described the law as a "good start" and that "to be prepared for bioterrorism, it is imperative that we develop a cohesive and comprehensive system of ongoing surveillance and case investigations for early detection". In this way, several early detection systems have been implemented with different levels of success among different geographic regions in the US.

One of the most important initiatives over the years has been the establishment of the National Electronic Disease Surveillance System (NEDSS) (Baker and Koplan 2002; NEDSS 2001). The National Electronic Disease Surveillance Working Group establishes that the "NEDSS is a broad initiative focused on the use of data and information systems standards to advance the development of efficient, integrated, and interoperable surveillance systems at the state and local levels. The long-term objectives for NEDSS are the ongoing automatic capture and analyses of data needed for public health surveillance". The purpose of this system is to take into consideration and integrate the information of current public health systems implemented at different health department levels: county, state and finally at the Centers for Disease Control and Prevention (CDC).

Another initiative spearheaded by the CDC is Biosense (Looks 2004). The purpose of this program is to develop advance detection capabilities of health related events including disease outbreaks. In addition, its emphasis is to improve situational awareness by integrating advanced analytics to process data generated by different health providers and other entities in the US.

Now that we have examined the general aspects, we will continue our background review focusing on the aspects that pertain to the specifics of the dental profession.

4.3.3 Dentistry in the US

This section will provide some perspective of the structure of the dental profession in comparison with its medical counterpart. "There are approximately 150,000 active dentists in the United States" (Mertz and O'Neil 2002). In 1990 the dentist-to-population ratio was of 60–100,000. And it is expected that by the year 2020 the ratio will be 52.7, which translates into one dentist for every 1,898 people. "In contrast, the physician-to-population ratio has been increasing for the past 40 years and now stands at 286 per 100,000, about one physician for every 349 people." Eighty percent of the dentists are in general practice.

4.3.4 Dentistry and Bioterrorism

During March 27 and 28 of 2003, the American Dental Association and the US Public Health Service sponsored the conference "Dentistry's Role in Responding to Bioterrorism and Other Catastrophic Events" (Palmer 2003; National Institute of Dental and Craniofacial Research 2004). This meeting reviewed several aspects of bioterrorism and the dental profession: the nature of biological pathogens and its oral manifestations, what needed to be communicated, how dentists should participate, etc. Dr. Michael C. Alfano described the difficulties that biological pathogens create for clinicians because "they are so insidious." While discussing the anthrax mailings after September 11th he pointed out that: "… early symptoms appeared so they resembled the aches, fever, and malaise of flu so those affected delayed seeking treatment, a delay that has proven fatal in some cases". Lieutenant Colonel Ross H. Pastel of the US Army Medical Research Institute of Infectious Disease (USAMRIID) listed the "Category A" pathogens as defined by the Centers for Disease Control and Prevention, and those are: smallpox, anthrax, plague, botulinum toxin, tularemia and viral hemorrhagic fever. He also described an outbreak of smallpox in Yugoslavia in 1972 and the measure that had to be taken to control it. Dr. Michael Glick described the oral manifestations of smallpox showing "signs 24 hours before skin rash. These oral signs include tongue swelling, multiple mucosa vesicles, ulceration, and mucosal hemorrhaging. Oral signs are also evident in inhalation and gastro-intestinal anthrax. In oropharyngeal anthrax the mucosa appears edematous and congested; there may be neck swelling, fever, and sore throat".

Dr. Ed Thompson, Deputy Director of the Centers for Disease Control and Prevention mentioned that "None of the new counter-bioterrorism measures can be effective unless local health practitioners are vigilant in observing and reporting a possible disease outbreak. Such surveillance–knowing what to look for and whom to report to–is critical and applies not only to suspected bioterrorist agents, but to a list of reportable diseases which has grown to include such entities as West Nile virus and Sever Acute Respiratory Syndrome (SARS)." Dr. Sigurs O. Krolls presented the response at the local level and he "stressed the importance of communication and the need for redundant systems", "to keep all the parties informed". He also posed the question "Can dentists recognize signs and systems of contagious diseases?", and emphasized that education can be essential. Dr. Louis DePaola made several connotations that can be key in the scope of this paper by saying "dentists can contribute to bioterrorism surveillance by being alert to clues that might indicate a bioterrorism attack. Such surveillance would note if there is an influx of people seeking medical attention with non-traumatic conditions and flu-like or possibly neurological or paralytic symptoms… or even specific signs of a bioterrorist agent. Patterns of school of work absence, appointment cancellations or failures to appear, could also be indicators." Dr. DePaola made clear that in cases of limited release of bioterrorist agents, dentists "have little to offer" but "a widespread attack can certainly tap into dental professional skills in recognition, isolation and management". In addition, Dr. Guay (2002) lists all the possible roles in which dentists can participate including "education, risk communication, diagnosis, surveillance and notification, treatment, distribution of medications, decontamination, sample collection and forensic dentistry."

Dental Informatics must pay attention to these and other recommendations, in order to develop integrated systems that take these recommendations into consideration. It is also important to understand that informatics has to work with technologies already in place like the Computer-Based Oral Health Record and current standards. The final recommendation from the meeting stated that to play an important role in biodefense, a serious amount of coordination and preparation will be required, not only from dentists but from other groups, most likely requiring medical and dental data integration.

4.3.5 The Computer-Based Oral Health Record (COHR) and Computer Ownership

The COHR as described by Rhodes (1996) "can provide a structure for documentation that goes beyond the concept of a blank form on a page, it includes a glossary of dental terminology for the entire content of the form as well as knowledge bases and expert systems that can enhance the practitioner's diagnostic and treatment planning decisions". He also acknowledges that one of the advantages of this type of documentation is that it "is much more transportable". He also recognizes the need for standardized methods for collecting information from dentists. Schleyer and Eisner (1997) defined several scenarios where the COHR is used in a "shared" environment where several healthcare providers interact and information is seamless communicated, improving the decisions made by clinicians. Delrose and Steinberg (2000) discuss how the "Digital Patient Record" enhances clinical practice by providing "better quality information" to the clinician. Although all of these benefits sound promising and encouraging some still express concern of the lack of standards among different information systems, which translates in communication breakdowns (Schleyer 2003). On the other hand, Heid and colleagues (2002) mention a list all the steps that are currently being taken by different organizations such as the ADA in order to produce a standardized COHR. Other examples of standardization can be found in a paper presented by Narcisi (1996) where ADA's participation as a voting member in the American National Standards Institute has allowed EDI or the COHR to be discussed and improved at a national level.

Additional influences in the standardization of the COHR are the security regulations mandated by HIPAA, the Health Insurance Portability and Accountability Act of 1996. Dentists are required to "adopt practices necessary for compliance" (Sfikas 2003; Chasteen et al. 2003). These and other regulations (Szekely et al. 1996) will encourage the homogeny among different system vendors. Computer ownership, on the other hand, has increased steadily during the last 25 years. According to Schleyer et al. (2003) in 1976 only 1% of dental professionals used computers in their practices compared to 85% in the year 2000. Additionally similar trends in Internet connectivity where described.

4.3.6 Dentists, Source of Information Against Bioterrorism

The issues mentioned above describe the issues that have to be considered in order to create surveillance system against bioterrorism for the dental profession. This review has tried to be inclusive by covering different aspects starting with the current state of affairs and environment, treats, technology, law, etc. Next we present a blueprint for developing a biosurveillance system.

4.3.7 Proposed System

The purpose of developing an electronic health surveillance system is to gather information from patients directly (Wagner et al. 2006) by detecting signs and/or symptoms, or indirectly by obtaining other types of information such as over the counter medication sales, patients' no-shows, usage of Internet search engines keywords, etc. In this particular case, the proximity of contact between the dentist and the patient is equivalent to a medical inspection in terms of immediacy and/or closeness. Such signs and symptoms can be easily detected if the dentist is properly prompted to search for them. This is just one example of ways how a system could provide assistance in the detection of a bioterrorism incident.

But, before describing our proposed system, it would be important to address the fact that current syndromic surveillance systems have certain advantages in terms of its particular technological implementation (Tsui et al. 2003). The RODS laboratory obtains data directly from chief complains in the emergency departments from hospitals. The advantage of this surveillance system is that the implementation has to be made with only a limited number of parties (hospitals, clinics, health systems, etc.). On the other hand, our system would have to deal with thousands of different implementations (one in each dental office). This and other challenges have to be considered when designing the proposed system:

The proposed system should work at multiple levels:

- The system would have to provide a mechanism to alert the dentist if there is suspicion that a bioterrorist attack may be happening. The mechanism would increase the dentist's awareness in case of finding suspicious signs or symptoms in a patient. This can be triggered by the patient's characteristics such as geographic location of residence, etc.
- Automated collection of information from the patient's oral health record. The system would report to a central database signs or symptoms of interest. The aggregation of this data could generate information that would eventually identify the presence of patterns that may lead to the early detection of such events.
- Collection of additional information, which combined with other sources, can be useful in terms of detecting or tracing some incident. Patients' "no-shows" is the primary example, that, if combined with others such as work or school absenteeism can provide a relevant pattern for public health officials.

4.3.8 Example of a Hypothetical Case

Dr. X, who practices in a community 20 min away from Capitol City, installed a new clinical management system 2 months ago. Among the features that were included in this new clinical management system (CMS), a bioterrorism detection module was added. She felt curious because of recent news she read in the newspaper about possible attacks against the US and decided to install such feature. He read about how the module would work in combination with the CMS she just bought. The educational information provided with the software instructed Dr. X, that in case that a patient victim of a bioterrorism attack happens to be seen in her practice, the software would collect information and would send it to public health officials. When installing the software, Dr. X was asked if she agreed to share such information with authorities. She was provided the option to receive notification in case some information was sent but she decided not to enforce it.

Fig. 4.25 Biosurveillance systems should be cognizant of different kinds of events since this can be linked to issues of public health concern

During the last week a patient walked into Dr. X's dental office. The patient presented some signs that indicated the presence of a disease; still its origin was not clear. An epidemiologic study later would show that the patient was present at the football stadium when an infectious agent was released (Fig. 4.25). Although, at that time his medical history showed no indication of a systemic disease, the presence of multiple oral vesicles prompted the dentist to make an annotation into the COHR. The system, by using a natural language processing engine, detected such sign and sent this information to a central database. The patient was discharged and instructed to take some support medication to treat the oral ulcers. The next day, the central database pinpointed the presence of an out of the ordinary increase in the number of cases with the same signs and symptoms around that region. When the presence of this peak was detected, the central server sent a request to the dentist computer for additional information. One of the requested elements was if there was any use of medication for treating oral ulcers. Fortunately this information was available. The central database crossed this with the information of other surveillance systems together with the information from other patients that happen to have similar clinical signs and/or symptoms. Dr. X received an email from a public health official asking her to communicate to the local health department to discuss information about one her patients.

The case depicted above simulates the release of smallpox during a football game. In the case of smallpox oral symptoms include tongue swelling, multiple oral mucosal vesicles, ulceration, and mucosal hemorrhaging (National Institute of Dental and Craniofacial Research 2004). Dentists could be alerted by an electronic system to search for such signs or they can be detected automatically. In case of a high incidence within a group of patients, in a confined area, public health officials get to be notified.

In our hypothetical case there are issues that need to be addressed in order to make such detection system feasible:

4.3.9 System Design

As described by Schleyer et al. (2006), 85% of dentists in the US use a computer in their practices. This figure would generate an estimate of 127,500 computers in dental practices. This prevalence of computers represents an opportunity for public health data collection.

The creation of a software application for surveillance purposes must rely on existing technology. Currently there are approximately 20 major clinical management software packages in the market (Dentistry Today 2003). Out of these 20, 17 clearly permit direct database manipulation. This characteristic can easily allow the creation of a "querying" application that would look for specific information within the data stored by those packages. Additionally, a natural language processing engine could be embedded into the application in order to detect variations in data input on the computer oral health record. Nevertheless, it is necessary to obtain a detailed list of the oral manifestations of diseases that are likely to be found on patients. Successful implementations of similar systems have been shown to work successfully (Chapman et al. 2001; Ivanov et al. 2002) and using the same approach for our system seems technically feasible.

This collected information later would be send to a central server in order to be analyzed and interpreted.

4.3.10 Software Architecture

The components of our system would be as follows (Fig. 4.26):

- Thin client: a software application distributed for data collection. It would be conformed of a "querying" mechanism, combined with a natural language processing engine and a communication module. This software client should be as thin as possible to reduce the work load on the dentist's equipment and should be embedded as a plug-in for current clinical management systems. Vendors should be contacted to ask for their collaboration in the development of such application to ensure maximum compatibility and integrity of data collection.

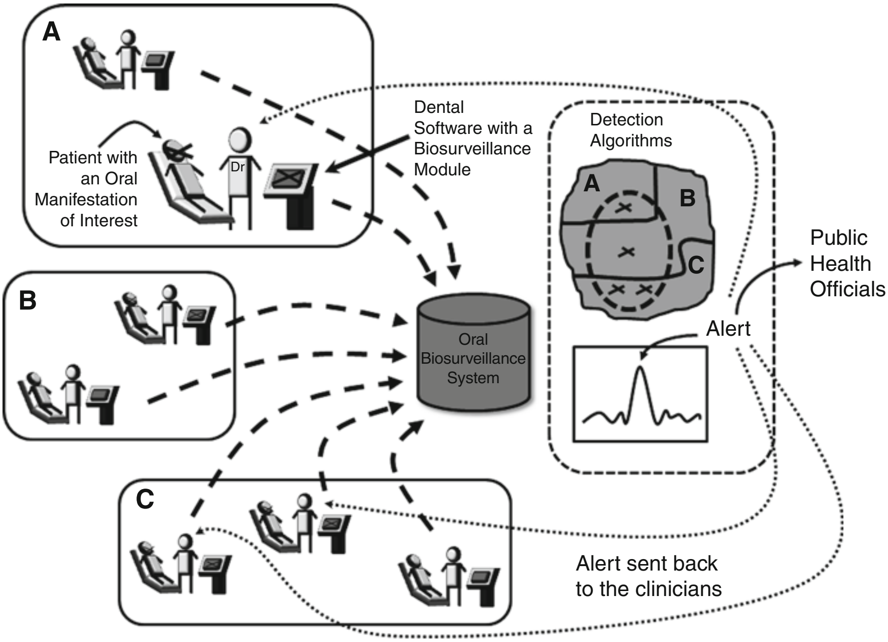

Fig. 4.26 Biosurveillance system architecture

- Central servers: server software in charge of integrating all the data collected from dental offices. It has to be capable of handling simultaneous requests from multiple users. This server would integrate all the data and would perform an analysis with the intention of detecting anomalies. It would be recommended that redundant servers should be located in different data centers with mirroring capabilities to guarantee their survivability in case of technical difficulties.
- Communication network: the transmission of information should be done using the Internet. This, of course, would essentially depend on the practitioner's current connectivity. If that is not available, backup connection to the central servers should be established.

4.3.11 Standards

Dentistry uses several standards for transmission of health related information. Clinical management systems use standard-based technology to transmit information (Narcisi 1996; Chasteen et al. 2003; Szekely et al. 1996; Dentrix Dental Systems 2011). Dentists are aware of these standards and use them in a day-to-day basis to transmit information to insurers. Additionally, in order to interact with other surveillance systems such as the NEDSS, our application should rely on the same standards.

4.3.12 Security and Redundancy

The software both client and server should be thoroughly verified to be secure in terms of being safe against hacker attacks. On the server side, redundancy should be provided so downtime is reduced from design. The system should be developed so mirrored servers are always up and running. Data integrity mechanism should also be considered.

4.3.13 Privacy and Confidentiality

Privacy and Confidentiality are important issues that need to be incorporated as part of a robust biosurveillance system and distinct regulations such as HIPAA require protecting patient information (Frist 2002; Chasteen et al. 2003; Bayer and Colgrove 2002; Etzioni 2002; Ivanov et al. 2002). In our hypothetical case we describe the use of several sources of information for detecting a bioterrorist attack. We described how syndromic information is transmitted to a central database which initially should be de-identified. Later, after the suspicion a bioterrorist attack more information is requested (medications) and more inferences are made. This, although technically possible, would require changing our processes and also the will to share clinical information. This leads to the discussion mentioned in the background section about "individual rights" vs. "common good". Although HIPAA addresses public health (Gesteland et al. 2003), some other implications may arise and the health professionals including dentists, physicians, public health officials and patients should discuss and address such issues.

As discussed earlier, legislators face a difficult task in terms of determining what is best on behalf of the individuals they were asked to represent. Legislation may have to be passed in order to guarantee the functioning of such a system. Individual freedom and privacy are important values which may pose a conflict when collecting individuals' information even for their own good.

In any case, careful consideration has to be given to which information is required to detect a bioterrorist attack and also, by keeping in mind that it is always important to reduce, as much as possible, the collection and transmission of patients' information over the Internet or any other network.

4.3.14 Detection Algorithms and Evaluation

A detection algorithm has to be created or adapted in order to determine the presence of a bioterrorist attack. Some algorithms have proven their effectiveness (Wong et al. 2003a, b) and it is likely that from these, a new analysis should be done in order to select or create one that addresses the particular needs of our system.

A study was conducted to assess the feasibility of using oral manifestations in order to detect disease outbreaks (Torres-Urquidy et al. 2009). It was found that for diseases such as Botulism and Smallpox it would be feasible to gather data that contains oral manifestations that would allow creating a detection signal using natural language processing followed by the use of statistical methods such as Moving Average to serve as part of a detection algorithm.

The system should also be thoroughly evaluated, before and after implementation. To perform the evaluation before the system implementation computer simulation can be used to assess the effectiveness and likelihood of detection. Simulation and modeling techniques (Reshetin and Regens 2003) have been used to estimate the effects of a bioterrorist attack. The same techniques can be used to evaluate our system. In case of the study by Torres-Urquidy (2009), the investigators utilized synthetic outbreaks to test the performance of different signals. From their evaluation process, they learned, for instance, how many cases would be necessary to occur for the system to reach certain detection thresholds.

4.3.15 Organizations Interested in Participating in Our Efforts

Several dental organizations have shown publicly their support of measures against bioterrorism. The American Dental Association and the National Institute of Dental and Craniofacial Research are two organizations who could play an important role in the development, deployment and ongoing support for our system. Local dental societies also would also play an important role in the deployment of the proposed system. Similarly, local, state and federal public health agencies should engage in activities that could make these mechanisms for health surveillance feasible.

If dentists want to play an active role in the fight against bioterrorism, they should commit to collaborate with public health entities as well as to seek a way to integrate their information with the rest of electronic biosurveillance systems. Professional organizations such as the American Dental Association can also participate by endorsing such efforts and by collaborating in the educational process of the dental professionals and their patients.

4.3.16 Conclusion

As mentioned by Dr. DePaola (National Institute of Dental and Craniofacial Research 2004) dentists "have little to offer" in the current biosurveillance state of affairs. However, the integration of different technologies can change this perception. Goldenberg et al. (2002) described over-the-counter medication sales as a technique for discovering disease outbreaks and stated that their approach may be "more timely" than traditional medical or public health approaches. Medical cases that result from bioterrorism attacks do not produce symptoms until they have fully developed, so it is likely that different patterns can be detected before the patients start reaching the Emergency Department. As stated earlier (Torres-Urquidy et al. 2009), it may be possible to have dentists participating of biosurveillance efforts, if we solve the proper organizational and technical challenges.

Dr. John R. Lumpkin (2001) states that “Hippocrates noted the health of the community was dependent on characteristics of a community and the habits of the people who lived there.” Dr. Krolls (NIDCR 2003) in his final remarks during his presentation at the Dentistry’s Role Conference Against Bioterrorism, said, “dentists may pick up telltale information about what is happening in the community. After all, dentists spend more time with their patients than any other health specialty”.

Further Reading

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4.4 Integration of Patient Records and Clinical Research: Lack of Integration as a Barrier to Needed Research; Integration as a Prerequisite to Research

Muhammad F. Walji

4.4.1 Introduction

Maintaining patient records are essential for both clinical care and research. Clinical research often occurs in the context of also providing patient care, yet the systems that are used for each are different and often cannot exchange data. The lack of data exchange between systems pose significant barriers to efficiently treating patient and conducting clinical research in dentistry. The purpose of this section is to review the benefits and challenges of integrating electronic health record (EHR) used for patient care and electronic data capture (EDC) which is used for clinical research such as clinical trials.

An increasing number of dentists routinely use EHRs (Schleyer et al. 2006). Most dental schools in North America also use EHRs. Benefits of using EHRs include increased legibility, portability, and improved patient safety (Buntin et al. 2011). Recent federal incentives, although not directly beneficial to dentists, will also likely spur the adoption of EHR (Blumenthal and Tavenner 2010).

Clinical researchers, especially those conducting clinical trials, are also discovering benefits of using electronic data capture compared to paper. A clinical trial is a process in which new treatments, medications and other innovations are tested to evaluate safety and efficacy. A standard part of health care, clinical trials are often lengthy and costly due to myriads of regulatory oversight. Recent estimates set the cost of drug development in excess of $800 million (Grabowski et al. 2002).

4.4.2 *Electronic Health Records and Electronic Data Capture*

Accurately documenting data with sufficient detail is critical for providing patient care and conducting clinical research. While the medical record is the foundation for patient care, the case report form is the foundation in a clinical trial. Not all clinical research is clinical trials. Clinical trials whose data will be submitted to the FDA as a new therapy or device have additional requirements relating to the collection and transmission of the data. Similarly for patient care data, EHRs need to meet the privacy and security requirements of HIPAA.

Case report forms (CRF) are a medium in which research study sites collect subject data in pre-defined formats for communication with clinical trial sponsors (Rondel and Webb 2000) Many clinical trials data are collected on paper (Rondel and Webb 2000). Data measurement, collection, and recording are considered the "most crucial stage" in the data management process (Hosking et al. 1995).

Traditionally, study coordinators often record information in a case report form and subsequently mail or fax the CRF to the centralized coordinating center. There, data entry staff, sometimes with the aid of optical character recognition systems, input CRF data into a computer. Errors made during this second data entry process are difficult to detect and correct (Hosking et al. 1995). Lengthy guidelines in literature discuss methods for developing paper case report forms to reduce data entry mistakes (Hosking 1995). A well-designed CRF may allow a user to efficiently collect and record pertinent data. However, forms are often revised and redesigned during a clinical trial due to changes in protocol, unforeseen outcomes, or oversight (Singer and Meinert 1995).

There has been a recent drive to use electronic case report forms (eCRF). Direct data entry at a study site shortens time to analysis and provides opportunities to audit data at time of entry. This could reduce data errors that might otherwise be caught weeks after submission. For quality control purposes, some studies require double data entry using computers and paper (Day et al. 1998), though alternative solutions have been explored including the use of data sampling (King and Lashley 2000) and probability statistics to select only those forms likely to contain errors (Kleinman 2001).

ECRFs may also facilitate data collection from existing electronic information systems such as lab systems. However, eCRFs are almost always reside in a separate system that is not linked to a patients record.

Although many clinical research studies are still being conducted using paper, an increasing number of studies are using eCRFS and electronic data capture (EDC). For example, a review of Canadian clinical trials found that 40% use EDC (El Emam et al. 2009). Studies that are sponsored by a pharmaceutical company and are multicenter appear to use EDC at a higher rate than those sponsored by government or a university. The cost of a commercial EDC is substantial. Recently a freely available EDC has become popular amongst universities called REDCap. A tool originally developed at Vanderbilt University, it is now being used at over a 100 institutions worldwide (Harris et al. 2009). However, such tools are generally not integrated with the institutions EHR. Although moving from paper to electronic will afford benefits there is a great need to allow data exchange between the patient care and clinical research components of information systems.

Although EHR and EDC are similar, several challenges remain unresolved that prevent integration. One of the major barriers is likely to be different workflows for patient care purposes and to collect data for research. Research is needed in defining an optimal workflow that can streamline the tasks associated with patient care and research, while at the same time providing a unified information system that support these activities. Also, the data that are collected for care and research are likely to differ. A researcher may require far more granularity of an oral health measurement than a clinician seeking to provide care. In cases when conducting a double blind placebo controlled clinical trial, the investigator may not even know the type of treatment that has been delivered to the patient. Due to complexities of each domain, and large differences in goals, to date mutually exclusive workflows have arisen. A clinician investigator who sees a patient for both care and research, will likely need to enter data on this same patient twice; once in the EHR and once in the EDC system.

4.4.3 Need for a Common Language

Despite the availability of electronic systems, a major barrier is the integration and compatibility of disparate health information systems to converse with one another. The languages are important because they can help data sharing. Clinical trials are not usually conducted in isolation, but are part of conventional medical care. Therefore sharing data by clinical trials, patient care and laboratory systems becomes especially important with the adoption of EHRs in dentistry.

In biomedical informatics, standardized terminologies are recognized as a critically important area to help better represent and share data for use in electronic systems (Cimino 2000).

The Systematized Nomenclature of Medicine Clinical Terms (SNOMED-CT), developed by the College of American Pathologists, is the most comprehensive medical terminology (Strang et al. 2002; Chute et al. 1996) and is used in a number of health informatics applications. The US Department of Health and Human Services (2010) has also licensed SNOMED-CT, allowing access throughout the US at no charge. Therefore SNOMED-CT is even more likely to be the vocabulary used in electronic formats of patient records in the future.

The Medical Dictionary for Regulatory Activities (MedDRA) is terminology used by the FDA and drug development industry to classify, retrieve, present, and communicate medical information throughout the medical product regulatory cycle (Brown et al. 1999). In particular it is used to record and report adverse drug event data.

Therefore standard languages are essential in sharing clinical trials data between sites, and also with regulatory agencies. No one single terminology is suited for all tasks. SNOMED-CT is likely to be more comprehensive to code clinical encounters, while MedDRA is more suited to help adverse event reporting. However, it is important that terminologies are widely adopted and used for similar purposes.

Even when standard terminologies are agreed upon, such information needs to be interchanged in standard formats. Health Level 7 (HL7) is an important organization whose standards are widely adopted in healthcare to exchange information between computer systems. The Clinical Data Interchange Standards Consortium (CDISC) is also an important group that helps to define different data standards specifically for clinical trials research, such as clinical trials or regulatory submissions.

One particular challenge in oral health has been the lack of a standardized terminology to describe diagnoses. Although ICD contains oral health concepts, they are often not granular enough to be useful for some patient care or research purposes. Recently a dental diagnostic terminology has been developed by a group of dental schools, and has already been adopted by several institutions and used within dental EHRs (Kalenderian et al. 2010). The American Dental Association (ADA) has also been developing SNODENT, but is not yet publically available for clinical use (Goldberg et al. 2005).

4.4.4 Cohort Selection and Patient Recruitment

Another link between EHR data and clinical research is the potential to find human subjects. Recruiting sufficient numbers of patients that meet eligibility requirements within an allotted time frame for clinical trials is challenging. As EHRs contain detailed information about patients, they can be used to find patients that meet specific inclusion and exclusion criteria. Informatics for Integrating Biology and the Bedside (i2b2), an open source data warehousing platform, has been found to be a useful tool for cohort selection especially if the source data from an EHR is represented in a structured format (Deshmukh et al. 2009).

Further, with health information increasingly available to patients through the Internet, it is possible interested patients will be more effective in finding clinical trials than investigators looking for patients. Many clinical trial registers are now available online. The National Institutes of Health (NIH) have made available their database of NIH funded research (McCray 2000). There is currently no single repository for patients to find all trials studying a health condition. A recent study assessed the comprehensiveness of online trial databases concerning prostate and colon cancer and found that online trial registries are incomplete, especially for industry-sponsored trials (Manheimer and Anderson 2002). A more collaborative effort between government and industry-sponsored research groups to compile and standardize information may be a mutually beneficial effort. It is not clear how many patients now enroll in clinical trials through online discovery.

4.4.5 Secondary Use of EHR Data

EHR data originally collected for patient purposes can be potentially used for research. Aggregating data from multiple sources can provide a large dataset that could otherwise not be available.

Electronic health records (EHR) contain a wealth of information and are a promising source to conduct research. Data extracted from EHRs differ from other sources such as population surveys or data obtained from payers, as they provide a more detailed and longitudinal view of patients, symptoms, diseases, treatments, outcomes, and differences among providers. Therefore EHR data in dentistry can potentially provide valuable insight into oral health diseases, and treatments performed on a large cohort of subjects. EHRs also play an important role in enhancing evidence-based decision-making in dentistry (EBD) and improving clinical effectiveness through decision support (Atkinson et al. 2002; Walji et al. 2007; Valenza and Walji 2007; Taylor et al. 2007; Spence et al. 2007; Chambers et al. 2007; Langabeer 2nd et al. 2008; Walji MF et al. 2009).

The Consortium of Oral Health Related Informatics (COHRI) provides an example of how dental EHRs are used for research purposes (Schleyer et al. 2006; Stark et al. 2010). COHRI was formed in 2007 by a group of dental schools who used the same EHR platform and who are interested in sharing clinical and education data. Through funding from the National Library of Medicine, four dental schools are participating in a pilot project to develop an inter-university oral health research database by extracting and integrating data from EHRs.

One promising area where data repositories derived from EHR data can be used for new discoveries is in the area of comparative effectiveness research. Comparative effectiveness research is defined as "a rigorous evaluation of the impact of different options that are available for treating a given medical condition for a particular set of patients." (Congressional Budget Office 2007) Further, such research includes focusing on the clinical benefits and risks of each option (clinical effectiveness), and an analysis on the costs and benefits (cost effectiveness analysis).

Comparative effectiveness research (CER) is also likely to reduce costs of dental care and increase access to the majority of the population who currently receive no dental care. Unfortunately many recent systematic reviews focusing on CER questions in dentistry have been inconclusive due to the lack of existing evidence in the scientific literature. Secondary analysis of the data that reside in dental electronic health records (EHR) is a particularly appealing approach to facilitate CER and generate new knowledge. EHR data has the potential to provide a comprehensive picture of patients' histories, treatments, and outcomes, and if integrated with similar data from other dental clinics can include a large and diverse set of patients.

However, numerous challenges must be solved before EHRs can be used for CER. First, data suitable for CER must actually be collected from EHR systems. Second, this data, which often resides in proprietary systems, must be accessible and retrievable. And lastly, this data should be structured in a format that can be integrated with data from other sources or institutions.

4.4.6 Practice-Based Research Networks

Practice-based Research Networks (PBRN) are groups of primary care clinicians and practices working together to answer community-based health care questions and translate research findings into practice. PBRNs engage clinicians in quality improvement activities and an evidence-based culture in primary care practice to improve the health of all Americans. In 2005, the National Institute of Dental Craniofacial Research funded three such research networks. The dental PBRN's to date have been conducting both prospective and retrospective research. For example, Barasch et al. conducted a case controlled study to investigate risk factors associated with osteonecrosis of the jaws (Barasch A et al. 2011). Many prospective studies conducted as part of PBRNs still require separate data collection systems for the research data.

EHR data contained in practices as part of PBRNs are beginning to be used for secondary purposes. For example Fellows et al. conducted a retrospective analysis of data contained in electronic health records to estimate incidence rates of osteonecrosis of the jaws (Fellows et al. 2011). PBRNs provide great promise of how EHR and clinical research data can be used effectively to promote both patient care and new discoveries.

4.4.7 Patient Registries

Another area that intersects both the patient care and research realm are patient registries. Patient registries are ways to track groups of patients who have had specific diseases or have had certain treatments. While EHR data would contain information on all types of patients, their diseases, and treatments, registries would allow focus on specific diseases or treatments of interest. Registries would not be as costly in terms of resource requirements like a traditional clinical trial, but would require specific eligibility criteria, informed consents, and collection addition to that collected as part of routing care. Dentistry has lagged far behind in forming data registries, primarily because dentistry is practiced in small offices and not in large hospitals making the process of integrating data very difficulty. However, dental schools which themselves house large clinical operations are ideally positioned to create disease specific registries that can potentially use data collected for patient care and extend for research purposes.

4.4.8 Future Directions

There is great potential for providing new insight in oral health by the integration of patient records and clinical research from both a workflow and information systems perspective. The technology challenges of developing systems that can exchange data, and use standardized terminologies appear solvable. However, the socio-technical issues such as determining how to incorporate optimal workflows for conducing both patient care and research with minimal additional overhead appear to be the greatest challenge before widespread adoption. Similarly, there appears to be great potential in using EHR data originally collected for patient care for the secondary use of research and discovery. This will require collaboration between patients, providers and researchers from all healthcare disciples, and institutions with friendly policies for sharing data to improve both patient care and drive new discoveries.

4.5 State of Health Information Technology and Informatics Within the Dental School in the United States

Amit Acharya, Andrea Mahnke, Po-Huang Chyou, and Franklin M. Din

4.5.1 Introduction

More recently there has been a strong push from the United States federal government for the adoption of the Electronic Health Record (EHR) within the healthcare industry. As a result, $19.2 Billion is made available to incentivize the physicians, dentists and hospitals for the adoption of the EHR through the Health Information Technology for Economic and Clinical Health (HITECH) Act. As the nation head towards adoption of the EHRs, there has also been a growing interest with the majority of the U.S. dental schools to implement EHRs within the educational setting. Fifty of the fifty-six U.S. dental schools, as well as dental schools in Canada and Europe, are either using or in the process of adopting some aspects of a common dental EHR framework (White et al. 2011). A group of dental schools known as Consortium for Oral Health-Related Informatics (COHRI) was formed in 2007 which used this common dental EHR framework – axiUm (Stark et al. 2010). Currently there are about 20 dental schools within COHRI. The EHR will not only support clinical care, but will also result in training the next generation dental students and to conduct innovative research that was not possible earlier. However, not much is known about how many of these dental schools' electronic dental records are integrated with their respective university's electronic medical record. A common medical-dental EHR model at healthcare universities would enable a holistic approach to providing patient care and provide the much needed electronic infrastructure to study interrelationship between the various oral-systemic diseases.

4.5.2 United States Dental School EHR Adoption Survey

Recently a group of researchers from Marshfield Clinic in Wisconsin, US conducted a survey to investigate the current states of Health Information Technology and Informatics within the dental school in the US. List of US dental schools were identified through the American Dental Education Association (ADEA) web site. Dental schools were contacted to determine who the most appropriate person to take the survey would be.

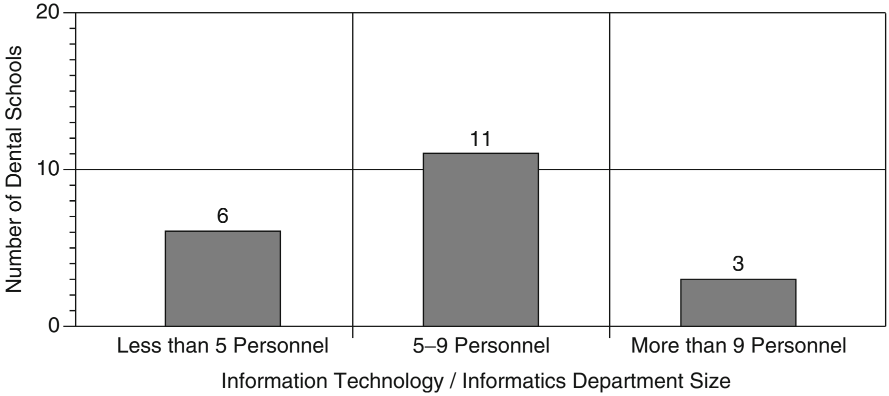


Fig. 4.27 Information technology – informatics department size at Dental Schools in US

Once the list of contact was developed from each dental school, an email was sent to 55 US dental schools with a link to a survey created in SurveyMonkey. The survey was administered on Tuesday March 1, 2011. Reminder survey emails were sent to all recipients on March 9 and March 17. The survey was closed on March 31.

The anonymous survey was at most 23 questions, depending on how questions were answered. The survey focused on topics such as presence of dental informaticians within the dental schools, use of financial and clinical information systems, interest in federal stimulus support for EHR adoption provided through American Recovery and Reinvestment Act and Meaningful Use of EHR, relationships with health care entities and bidirectional nature of the dental and medical EHRs. The study was approved as exempt from the Marshfield Clinic Institutional Review Board under section 45 CFR 46.101(b) and waived requirement for an authorization.

Thirty out of the fifty five dental schools responded to the survey (response rate of 55%). However, five of the thirty dental schools representative did not complete the survey and hence their response was not included in the analysis.

4.5.3 Key Findings of the Survey

4.5.3.1 Section 1: Dedicated Department/Center for Information Technology/Informatics

Regarding the question about the presence of a dedicated department or a center for information technology (IT) or informatics within the dental school in US, 80% (n = 20) of the responding dental schools had a dedicated IT/Informatics department or center (p-value of 0.0027). The IT or the informatics department size (in terms of the number of personnel) at the 20 dental schools is illustrated in Fig. 4.27.

Thirty five percent (n = 7) of the US dental schools that housed an IT / Informatics departments had personnel with not only IT training but also dental informatics training.

Fig. 4.28 US Dental School IT/informatics department personnel with and without dental informatics (DI) training

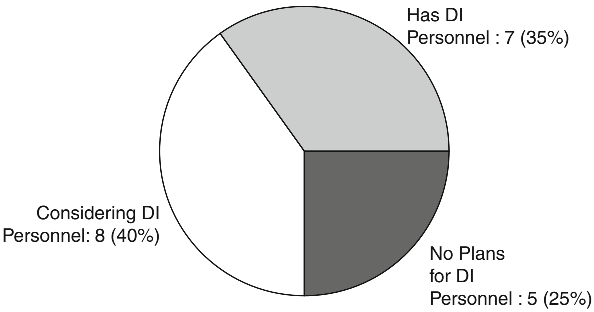


Table 4.6 Partial responses to additional question in Sect. 1 of the survey

	N	%
Do you know the ratio between numbers of employees in this department to the number of employees in your entire school? If yes can you provide the ratio?		
4%	1	7.14
50-1 excluding students, 100-1 including	1	7.14
5:1100	1	7.14
No	9	64.29
About 39:1, about 74:1 if you include students	1	7.14
Two/very many	1	7.14
What percentage of the school's operating budget is devoted to this department?		
1%	2	11.11
2%	1	5.56
5%	2	11.11
Don't know	10	55.60
By department, contract for services	1	5.56
It's high, but not sure how high	1	5.56
Small	1	5.56

While 40% (n = 8) of the dental schools were considering integration of dental informatics personnel within their department or center. Twenty five percent (n = 5) of the dental schools did not have any plans of integrating personnel with dental informatics personnel within their department or center (see Fig. 4.28). Partial responses to additional questions in the Section 1 of the survey is provided under Table 4.6.

4.5.3.2 Section 2: Current Use of Electronic Financial Systems and Electronic Dental Records

The majority of the responding dental schools were currently using Financial Electronic Systems (FES) (p-value of <0.0001) and Electronic Dental Records (EDR) (p-value of 0.0001). The use of FES outnumbered the use of EDRs in the dental

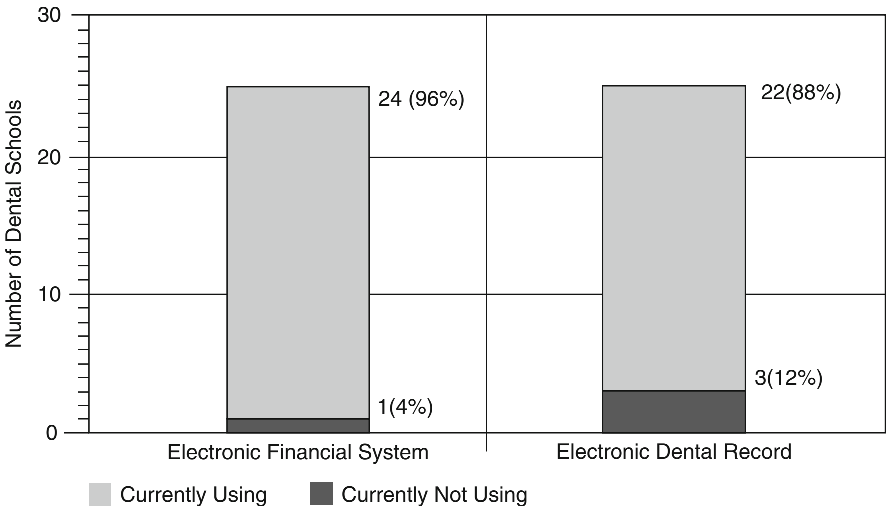


Fig. 4.29 Current usage of electronic financial systems and electronic dental records among the responded Dental Schools

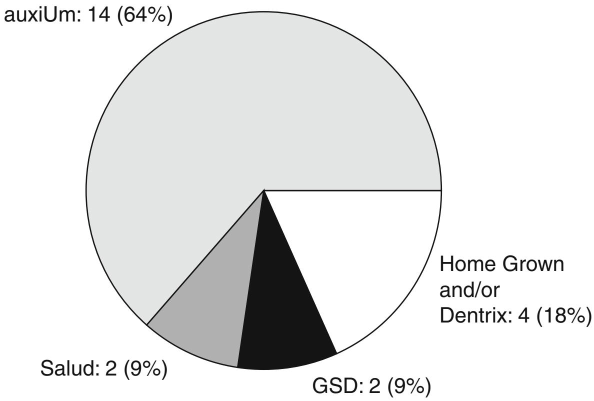


Fig. 4.30 Commercial electronic dental records used in the US Dental Schools

schools (see Fig 4.29). About 77% of the dental schools that were currently utilizing the EDRs used it in all the clinical modules (p-value of 0.0105), while 23% of the dental schools used the EDRs in some of the clinical modules.

When asked about the commercial EDR system that the dental schools were using, axiUm (Exan Group, Canada) was by far the most implemented EDR system. Two dental schools had Salud (Two-Ten Health Limited, Ireland) implemented and two dental schools had GSD Academic (General Systems Design Group, Iowa, US) implemented. Combinations of two EHR systems (Home Grown and Dentrix) were implemented at two dental schools. One school had a Dentrix only implementation, while another had developed its own EDR system (Home Grown) (see Fig. 4.30). There were 13 dental schools which had implemented an EDR five or more years

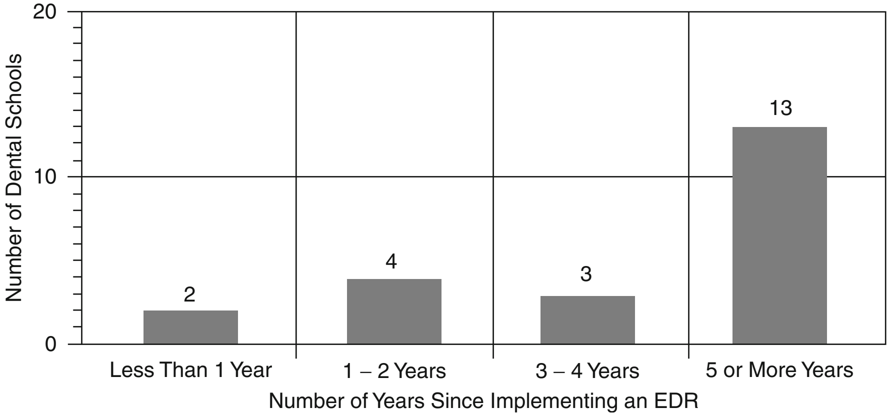


Fig. 4.31 Number of years since implementing an EDR at the US Dental Schools

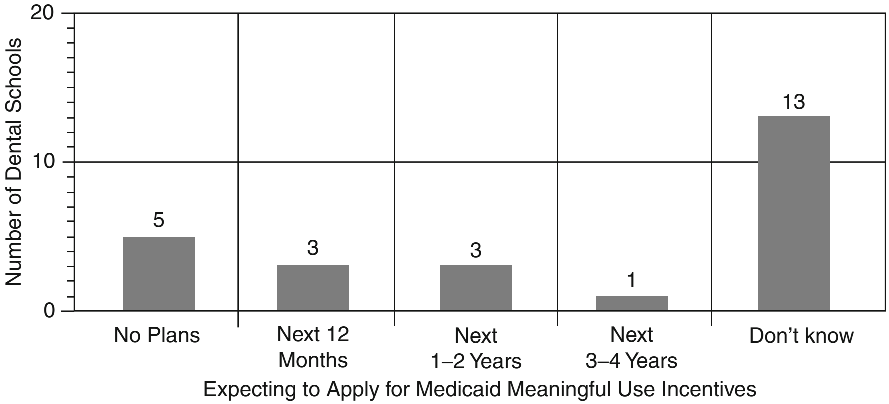


Fig. 4.32 US Dental Schools' plan for applying to medicaid meaningful use incentive program

ago, 3 dental schools 3–4 years ago, 4 dental schools 1–2 years ago and 2 dental schools less than a year ago (see Fig. 4.31) (p value of 0.0029).

4.5.3.3 Section 3: Medicaid Meaningful Use of EHR Incentives

When the dental schools were asked the question as to whether they were expecting to apply for the Medicaid Meaningful Use incentive program, majority (52%) of the dental schools did not know and only 28% of the dental schools were expecting to apply within the next 4 years (Fig. 4.32) (p-value of 0.0044). Challenges or barriers identified by some of the dental schools in complying with the Meaningful Use objectives were (a). lack of certified EDR and information regarding it, (b). issues with getting auxiUm certified and (c). qualifications of the EDR as many of the Meaningful Use objectives do not apply to dentistry and lack of specific information about it.

4.5.3.4 Section 4: Dental School and Health System Relationship

Only 44% of the responded dental schools were part of a health system. Fifty two percent (n = 13) of the responded dental schools had a formal relationship with other health care delivery entities in terms of sharing facilities, patient transfer, training programs. Some of the types of relationship mentioned by the dental schools that had a formal relationship with other health care delivery entities included: (a). a GPR program and an emergency dental unit in the hospital, (b). affiliated hospital, (c). affiliation agreements, (d). oral and maxillofacial surgery (OMFS), anesthesia and pedodontics all have some portion of education in medical health center, (e). OMFS residents are also residents of medical health center, (f). residents providing care under contract with area hospitals, (g). sharing patients wand facilities with the health center, (h). students rotating in the community health centers and (i) collaborative grand programs. Eighty five percent of the dental schools that had a formal relationship with the health care delivery entities had routine interaction with them because of their existing relationship (p-value of 0.0015). Their usual method for exchanging information was through informal medium such as phones, emails and faxes and formal medium such as memorandums, letters and contracts.

4.5.3.5 Section 5: Communication Between Health System's Electronic Medical Record (EMR) and Dental School's Electronic Dental Record (EDR)

When the dental schools were asked about the communication between the health systems' EMR and the school's EDR, majority of the dental schools did not have any communication (60%) or did not know is such a communication existed (25%) (p-value of <0.0001) (see Fig. 4.33).

Out of the 60% (n = 15) of the responded dental schools who's EDR did not communicate with the health system's EMR, 47% (n = 7) of the dental schools stated that they did not need to exchange patient information electronically as a reason for the non-communication, while 33% (n = 5) dental schools states that they would like to exchange patient information electronically but there were barriers that prevent them from doing so. Some of the barriers identified by these dental schools were (a). the hospitals and the dental school are not part of the same medial system and HIPAA concerns prevent sharing data, (b). the dental school currently neither did have an EDR nor the infrastructure to support one and (c). hospital is not interested and has high and perhaps unrealistic security standards. The remaining 20% (n = 3) of the dental schools expected to exchange patient information electronically in the near future (next 5 years). Some of the information categories that were shared between the EDR and EMR in the small number of dental schools are illustrated in Fig 4.34. Finally when asked about any research projects under way in their dental school to investigate discrepancies between medical and dental records for the same patient, only 1 (4%) dental school was currently undertaking such project.

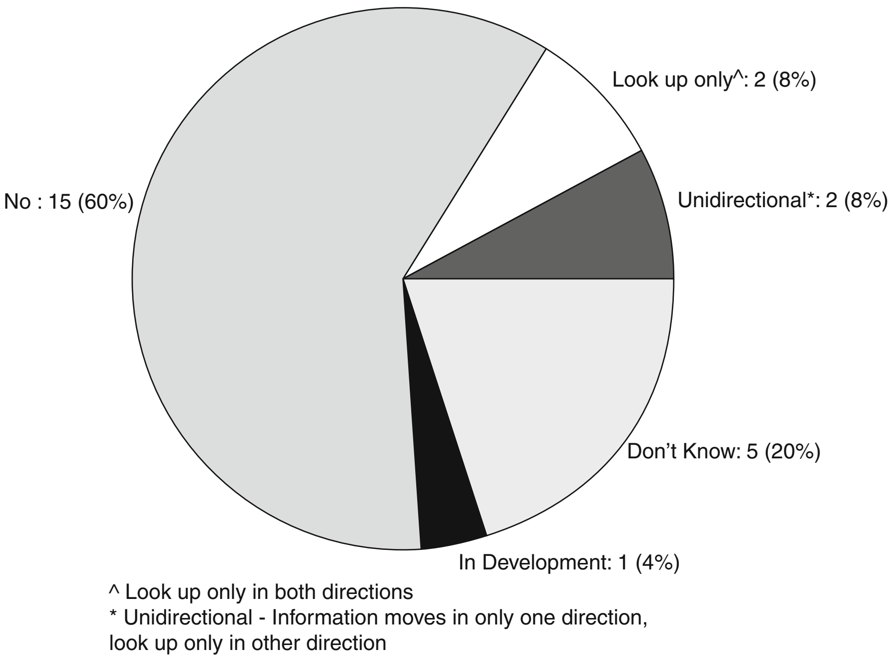


Fig. 4.33 Communication between EMR and EDR among the responding US Dental Schools

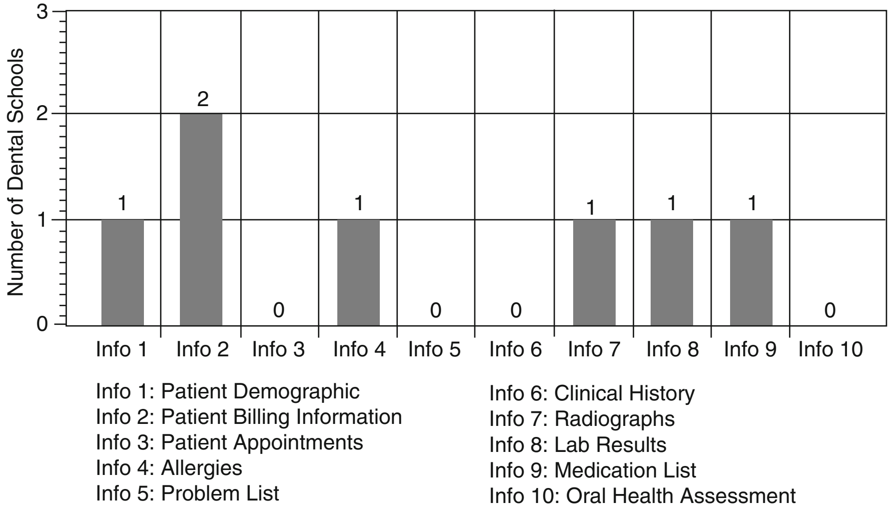


Fig. 4.34 Information categories shared between EDR and EMR in some of the US Dental Schools

4.6 Genomics/Phenomics/Proteomics/Translational Research

Steven J. Schrodi

4.6.1 Introduction

In all common diseases, including those that affect the oral cavity, both the environment and genetics are pathogenic conspirators. Unfortunately, we currently know little about the specific mechanisms underlying any common disease; and oral diseases are among the least understood. Elucidating the etiology of chronic oral diseases will involve a synthesis of results from careful experiments of environmental exposures such as diet and tobacco use, the oral microbiome, co-morbidities, large-scale, well-designed genetic studies, and the various interaction effects.

With regard to genetics, the past few decades have witnessed transformative developments in our ability to interrogate the entire genome for genes that contribute to disease. While dramatic advances in experimental designs, statistical approaches, and clinical insights have greatly aided this scientific campaign, the central driver of this progress has been the development of high-throughput, inexpensive genetic technologies. Following initial molecular studies using variant forms of enzymes, or allozymes, a major breakthrough was the use of highly informative DNA-based markers throughout the genome (Botstein et al. 1980). This idea of directly assaying existing DNA variation to conduct linkage and association studies in genetics began a revolution in disease gene mapping. Recent interest from commercial entities has produced a feverish pace of technological innovation, markedly reducing cost and expanding the depth of inquiry. Previously unfathomable, the testing of over one million single nucleotide polymorphisms (SNPs) in thousands of patients and controls is now commonplace (Wellcome Trust Case Control Consortium 2007; Schaefer et al. 2010); and very recently, next generation sequencing technologies have progressed to the point where sequencing of the entire protein-coding portion of the genome (exome) or even the entire genome is a cost-effective method to examine disease traits across the entire spectrum of genetic variants in small numbers of affected individuals (Ng et al. 2010). There is little doubt that soon whole genome sequencing will be applied to nuclear family-based designs, studies among distantly-related affected individuals in extended pedigrees, and case/control studies involving thousands of individuals. This unprecedented scope of inquiry made possible by large-scale genetics, has begun to yield fascinating resulting into predisposition to oral cancers, caries, and periodontal disease that will molecularly redefine these pathologies, explicate unique biological connections with related diseases, give impetus to the development of directed therapeutics, and indeed personalize medicine. Still, much more genetic focus on oral disease phenotypes is required if we are to realize this medical impact in a timely fashion.

As genetic technologies have allowed the progression of interrogating single protein variants to single DNA markers to entire genes to markers across the genome, and now to the entire genome sequence, the promises of these large-scale genetic studies have understandably undergone monumental expansion. It may be reasonable to expect the results from whole genome sequencing to decidedly revolutionize medicine within the next two decades. However, this new scientific capacity comes at a cost. As genetics, and biology in general, transitions to a data-rich science, practitioners have found themselves woefully unprepared to store and analyze the volume of data generated. Once analyzed, interpretation and integration of these abundant and multifaceted results into medical practice will also be an appreciable challenge. Insufficient assimilation of genetic findings into merged dental and medical records will severely limit the ability of clinicians to appropriately treat patients. Inadequately addressing these informatics issues will severely derail efforts in the basic sciences efforts as well as the translational and clinical sciences.

This chapter explores the current state of genomics studies, what we have learned from genetic investigations into oral diseases, and where we may be headed. Genetic studies have much to offer investigations of disease etiology. Why do some acquire diseases and others do not? For those affected, why do some progress more rapidly than others? What causes some patients to respond to therapies, while others suffer from adverse reactions? These are all fundamental questions in both biology and medicine, whether the focus is on the gastrointestinal tract, the hippocampus, the lymphatic system, metabolic disorders, or oral diseases. Speaking generally across disease areas, a portion of the answers to these questions often lies in described environmental effects. In numerous chronic diseases, infectious agents are likely contributors to the disease process – periodontitis, for example, is initiated by gram negative anaerobes in susceptible individuals (Holt and Ebersole 2005). Surely, unique and latent environmental exposures provide a random component to common disease susceptibility and progression. Through twin studies, studies of risk in close relatives, and quantitative traits experiments, it is well-understood that heritable factors, including but not limited to DNA variation, are typically responsible for 30–90% of the phenotype variability for common diseases. This section will attempt to cover, at least at a cursory level, the major salient developments affecting genetic insights into chronic and aggressive periodontitis, with some comment on genetic factors influencing susceptibility to caries and oral cancers. While it would be extremely naïve to view genetic studies as an immediate panacea for our ills, the discovery of disease-causing genes does illuminate hitherto unknown biological pathways and molecular mechanisms, draws unforeseen connections with other traits, may improve prognostic models applicable for individuals, and suggests specific therapeutics.

4.6.2 Oral Disease Phenotypes

4.6.2.1 Chronic Inflammation, Metabolic Dysfunction, and Infection

Industrialization has brought forth increased lifespan and wellness through vaccination, modern sanitation practices, public health policies, and advances in medical science translated into practice. However, the accompanying physical inactivity coupled with a high calorie diet are probable contributors to an extremely common, chronically inflamed metabolic syndrome (Hotamisligil 2006) that is thought to give rise to a multitude of intimately related disease traits: insulin resistance, compromised insulin signaling, hyperglycemia, obesity, dyslipidemia, hypertension, impaired kidney function, elevated liver enzymes and steatohepatitis, poor wound healing, neurodegeneration, vascular disease, pregnancy complications, accelerated immunosenescence, and periodontal disease (Ford et al. 2002; Ferrannini et al. 1991; Eaton et al. 1994; Holvoet et al. 2008; Speliotes et al. 2010; Eckel et al. 2005; D'Aiuto et al. 2008). These diseases often co-occur within the same patient and could be considered variable expression complications arising from a state of aberrant caloric flux that induces metabolic dysfunction and chronic, systemic inflammation. These features constitute a disruption in a fundamental homeostatic mechanism with intensifying pathogenic consequences. The rapidly increasing incidence and decreasing age of onset for this pathophysiological state have generated a major source of mortality and morbidity in modern cultures (Ford et al. 2002; Ferrannini et al. 1991; Weiss et al. 2004).

It is becoming increasing clear that many chronic diseases have an infectious component. There is relatively convincing evidence that many systemic, T-cell mediated autoimmune disorders may be initiated by infections. For example, from archaeological data, it is believed that an infectious agent – currently unknown – is necessary for rheumatoid arthritis (Firestein 2003), and both Guillain-Barre syndrome and rheumatic fever have well-described pathogeneses triggered by specific infections in susceptible individuals (Bach 2005). In many instances, oncogenesis and tumor progression can be traced to pro-inflammatory responses at the site of chronic infection (Coussens and Werb 2002), although it is not known whether these effects are mediated through the actions of the immune system, the infectious agents, or a combination thereof. Several cancers fall into this category including gastric adenocarcinoma (Uemura et al. 2001), cervical cancer (Walboomers et al. 1999), hepatocellular carcinoma (Saito et al. 1990), and Kaposi's sarcoma (Dictor 1997), all having unequivocal infectious agent etiologies. Recent findings of anti-inflammatory pharmaceuticals, particularly those that inhibit COX-1 and COX-2, reduce the incidence of certain classes of cancers are consistent with this view (Dannenberg and Subbaramaiah 2003, Rothwell Rothwell et al. 2010). In addition, there is moderate evidence that several bacteria – the most studied is *Chlamydia pneumoniae* – play a role in atherosclerosis and myocardial infarction (Saikku et al. 1988; Watson and Alp 2008), however the studies are not conclusive and antibiotic treatment does not appear to be effective (Andraws et al. 2005).

4.6.2.2 Periodontitis

Chronic periodontal disease is firmly footed at the intersection of infection, chronic inflammation, and metabolic dysfunction. Chronic periodontitis is characterized by inflammation of the periodontal membrane, slowly causing gingival recession and eventual bone loss. The proximate cause of periodontitis is the virulent oral microbiome. The involvement of gram negative anaerobes has been firmly established for the disease. Aside from the known oral pathogenic species *P. gingivalis*, *T. denticola*, and *T. forsythensis*, the so-called "red complex" (Holt and Ebersole 2005), new bacterial species associated with chronic periodontitis have also been described (Kumar et al. 2003). The advent of an extensive database covering the oral microbiome will surely propel such investigations (Chen et al. 2010).

Numerous studies have shown that periodontal disease covaries with many diseases, presumably due to overlapping molecular etiologies. Compelling meta-analyses demonstrate a highly significant synchronicity of obesity and periodontal disease (Chaffee and Weston 2010). In addition, the correlation between periodontal diseases/alveolar bone loss and frank metabolic syndrome is repetitively observed (Nesbitt et al. 2010; Andriankaja et al. 2010). Extensive work has also shown a strong role for both inflammation-related genes and circulating inflammatory markers in periodontal disease (Nikolopoulos et al. 2008; Bretz et al. 2005a, b). Treatment studies further support the link between periodontal disease and immuno-metabolic syndrome. These experiments have demonstrated a significant improvement in intermediate molecular markers of inflammation when chronic periodontitis in the presence of metabolic syndrome (Acharya et al. 2010) or type 2 diabetes (Iwamoto et al. 2001) was treated. Conversely, treatment of periodontal disease with reduction of bacterial load leads to greater glycemic control among diabetic patients (Simpson et al. 2010; Stewart et al. 2001). Given the high prevalence of periodontitis and the co-morbidity of metabolic syndrome with periodontal disease, these treatment experiments appear to suggest that the virulent oral microbiome could play an important role in the pathogenesis of systemic inflammatory metabolic syndrome, and is exacerbated by the syndrome. Certainly, further studies are needed to definitively answer this question.

As chronic periodontal disease seems to be a critical feature of sustained, systemic dysfunction of both metabolic and inflammatory networks, uncovering the genetic variants carried by susceptible individuals would not only provide much needed insight into the molecular pathogenesis of chronic periodontal disease, but would also markedly aid our understanding of the inflammatory metabolic syndrome and how it drives related co-morbidities. Such genetic studies may also shed light on the specific mechanisms that appear to improve cardiovascular, inflammatory, and diabetic outcomes when periodontal disease is treated, potentially leading to therapies and medical/dental intervention with greater effectiveness. Such studies may also provide clues to which subsets of individuals respond more effectively than others and why they do so.

Periodontal disease can also present in a rapid manner with aggressive bone loss and early-onset. This is termed aggressive periodontitis (Lang et al. 1999). In contrast to chronic periodontitis, there is often a greater degree of familial aggregation with aggressive periodontitis, and it is hypothesized that most aggressive cases may afflict individuals with one or more defective immune genes (Zhang et al. 2003; Amer et al. 1988; Machulla et al. 2002; Carvalho et al. 2010; Toomes et al. 1999; Hart et al. 2000; Hewitt et al. 2004). Mutations in the lysosomal protease, cathepsin C, have been shown to be responsible for some forms of aggressive periodontitis, along with complications associated with other inflammatory diseases (Laine and

Busch-Petersen 2010). The specific HLA variants thought to play a role in aggressive periodontitis, are also involved in infectious disease susceptibility and autoimmunity; and, interestingly, two of the non-MHC-linked regions, *FAM5C* and a locus on chromosome 9p21, have been implicated in myocardial infarction (Connelly et al. 2008) and may have action as a tumor suppressor in tongue squamous cell carcinoma (Kuroiwa et al. 2009). As with chronic periodontal disease, an infectious microbiome is heavily involved. However, in general, microbiome differences could not explain the presence of chronic versus aggressive forms of the disease, although in some aggressive periodontitis patients, a highly leukotoxic *A. actinomycetemcomitans* strain may contribute to the disease process (Mombelli et al. 2002). We currently do not fully know the differences between the genetic susceptibility factors for the chronic and aggressive forms of the disease.

4.6.2.3 Caries

The most prevalent chronic disease in both children and adults is dental caries (National Institute of Dental and Craniofacial Research). Caries formation is a complex disease with several interacting components form the environment and host genetics. Similar to gingivitis and periodontitis, caries have an infection-initiating etiology with acidification leading to localized demineralization. Epidemiological studies have long shown that diet is a strong predictor of caries formation; and the reduction in pH is exacerbated by high consumption of carbohydrates. The principal pathobacterial species are *Streptococcus mutans* and *Lactobacillus* (van Houte 1994). There are also several reports of positive correlations of caries with inflammatory diseases, although the association is not always repeatable. It is also not clear what proportion of the putative association with inflammatory disease is due to innate upregulation of immune networks in contrast to the immuno-modulating pharmaceuticals prescribed to those with inflammatory disease (Steinbacher and Glick 2001). Much of the effect is reported to result from lack of saliva volume (Steinbacher and Glick 2001). Interestingly, the presence of epilepsy may be associated with higher caries rates (Anjomshoaa et al. 2009). Fluoride is an effective antimicrobial agent that interferes with bacterial growth and metabolism (Wiegand et al. 2007). Hence, topical fluoride administration as well as ingestion of fluoridated water inhibits cariogenesis and caries progression (Ripa 1993). Amelogenesis is a key process involved in modifying the rate of caries formation. Both common variation and rare mutations in enamel formation genes such as amelogenin and enamelin are involved in caries rates (Patir et al. 2008; Kim et al. 2004; Crawford et al. 2007), the molecular actions of which are beginning to be revealed (Lakshminarayanan et al. 2010).

4.6.2.4 Oral Cancers

Over 35,000 new cases of cancers affecting the oral cavity and pharynx were expected in the United States for 2009, with deaths numbering 11,000 (Jemal et al.

2009). The majority of these malignancies involved solid tumors originating from cancerous changes in squamous cells of the mouth. Again, oral cancers have a complex etiology existing of entangled genetic, epigenetic, infectious, and dietary causes, further modified by tobacco, alcohol and other environmental exposures. As with most cancers, it is reasonable to expect that both germline and somatic genetic changes will be involved in carcinogenesis, tumor growth, and metastasis. Promoter hypermethylation of genes central to cellular growth, differentiation, DNA fidelity, apoptosis, and metabolic stability is an important facet of these cancers (Poage et al. 2010). Indeed, methylation-mediated silencing of genes involved in tumor suppression (e.g. the cyclin-dependent kinase inhibitor 2A), detoxification (e.g. *MGMT*), and apoptosis (e.g. the death-associated protein kinase-1) are commonly found in oral squamous cell carcinoma samples (Ha and Califano 2006).

4.6.3 Modern Genetics

4.6.3.1 Heritability

To quantify the proportion of the variance in a phenotypic trait that is due to variance in genetic factors, population geneticists defined the concept of heritability (Visscher et al. 2008; Falconer and MacKay 1996). Researchers subsequently developed several methods for estimating heritabilities using the measure of a trait (e.g. occurrence of disease/not-disease) in combinations of relatives (e.g. parent-offspring, or monozygotic-dizygotic twins). In general, the higher the measured heritability of a variable phenotype, the larger the contribution of genetic factors is in comparison to environmental effects. It is fallacious to assume that the heritable variation is composed entirely of alleles residing in the DNA sequence, for heritability studies simply examine the covariance between relatives without comment on specific molecular mechanisms. Hence, any heritable variation such as methylation patterns, vertically-transmitted infectious agents, as well as DNA variation can contribute to the heritability measure. Heritability results are important because they not only give a rough estimate of the collective effects of heritable factors, but also can provide a measure to quantify how much of the total genetic effect is accounted for by specific loci examined.

For periodontal disease, four twin-based studies of heritability have been performed (Michalowicz et al. 1991; Corey et al. 1993; Michalowicz et al. 2000; Mucci et al. 2005). Although varying in sample size and methodological details, all four arrived at consistent results, with 30–50% of the variance in periodontal disease being attributed to genetic variability for chronic periodontitis. Given the segregation patterns described in the literature, it is reasonable to assume that aggressive periodontal disease exhibits a higher heritability. Therefore, given the prevalence of periodontal disease, heritable factors within the population at large are likely appreciable. Using 314 twin pairs, Bretz and colleagues reported substantial heritability values for multiple traits related to caries ranging from 30% to 56% (Bretz et al. 2005a, b). Lastly, mutagen sensitivity studies of head and neck cancer patients suggest a significant effect of genetic factors for the carcinogenesis of oral cancers (Cloos et al. 1996). Hence, there is every reason to believe that a sizable pool of genetic and/or epigenetic factors await discovery for oral diseases.

4.6.3.2 Genetic Technologies and Disease Gene Mapping

Once the development of PCR (Saiki et al. 1985) was applied to the idea of using naturally-occurring DNA variation (Botstein et al. 1980), large-scale DNA-based studies of disease underwent a substantial acceleration (Schlotterer 2004). Genotyping of short, tandem repeated sequences (Weber and May 1989) – microsatellites – spurred on a wave of genome-wide linkage studies, which evaluate the co-segregation of disease state with microsatellite markers, for both rare Mendelian disorders as well as more common diseases with complex inheritance patterns. While the rarer traits with more coherent transmission patterns generally relinquished their genetic secrets to linkage analysis, more common diseases did not. In the mid- to late 1990s, several theoretical studies had shown that the power to detect disease-causing alleles is higher with association-based designs such as a case/control experiment or association in the presence of a linkage signal as in the transmission/disequilibrium test if the frequency of those alleles is high and the effects are moderate (Kaplan et al. 1995; Risch and Merikangas 1996; Jones 1998; Long and Langley 1999). However, to conduct genome-wide association studies presented an ominous obstacle for the genetic technologies at the time. The number of markers required to effectively cover the genome was prohibitively large as the chromosomal blocks in population-based samples used in association designs were expected to be small. Even within large extended families, the limited number of recombination events generates substantial chromosomal blocks passed through the pedigree, but researchers had both theoretical and empirical evidence that the blocks in population-based samples were on the order of 50 K base pairs for most large human populations. As the reader can imagine, the mean length of blocks that are shared by descent is inversely related to the product of recombination rate, the number of affected individuals and the number of meioses separating the affected individuals. In practice, even very large extended families segregate regions shared by affected members on the order of several million base pairs in length. However, once geneticists seriously considered large-scale studies using a case/control design where individuals are separated by say 5,000 meioses, it became clear that to adequately cover the much smaller shared regions across the entire genome, hundreds of thousands of markers would be required (Kruglyak 1999). Utilizing the human genome sequence (Venter et al. 2001; Lander et al. 2001), a number of studies at Celera Diagnostics provided an intermediate solution, where approximately 30,000 putative functional SNPs primarily located in genes were assayed through allele-specific PCR in a number of common diseases using a staged case/control design. These studies were successful in identifying several gene-centric polymorphisms associated with common diseases (Begovich et al. 2004; Cargill et al. 2007) (Fig. 4.35).

Concurrently, several groups had performed extensive sequencing and genotyping across the genome to produce a genome-wide map of haplotype structure (Hinds

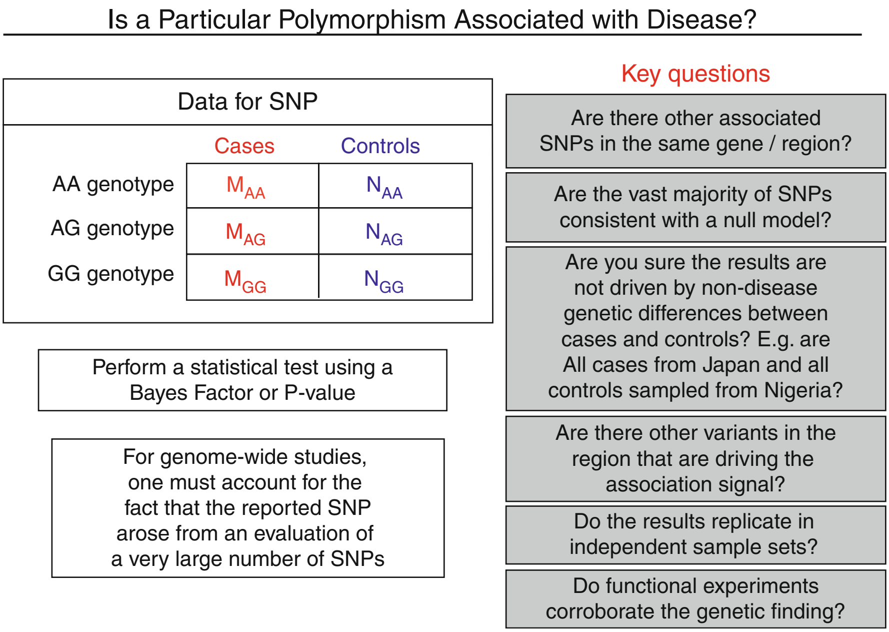
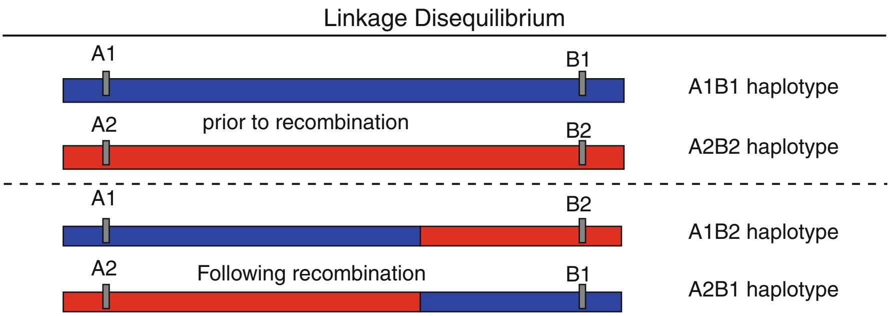


Fig. 4.35 Is a polymorphism associated with disease?

et al. 2005), useful in linkage disequilibrium mapping. Within 2 years, technology for SNP hybridization arrays had advanced so as to enable genome-wide association studies capable of capturing most of the common genetic variation in the genome either through direct genotyping or indirect interrogation using linkage disequilibrium – the term linkage disequilibrium is a measure of the correlation of alleles at closely-linked sites (see Fig. 4.36).

These investigations were met with numerous successes (Klein et al. 2005; Kathiresan et al. 2008; Graham et al. 2008; Gudmundsson et al. 2009). Inexpensive genotyping platforms and urging from theoreticians ensured that these genome-wide association studies were, in general, highly powered to detect all but very mild effects from high frequency alleles. These efforts, led by large academic consortia such as the Wellcome Trust, The International Multiple Sclerosis Genetics Consortium, and the Broad Institute and commercial entities such as deCODE genetics and Perlegen have greatly expanded our understanding of the basic biology of common diseases: we now know, for example, that (i) autophagy-related genes are involved in Crohn's disease (Rioux et al. 2007), (ii) there are a number of genes such as the protein tyrosine phosphatase, *PTPN22* and the interleukin-23 receptor, *IL23R*, that exhibit ample pleiotropic effects among autoimmune conditions (Lopez-Escamez 2010; Safrany and Melegh 2009), (iii) in the case of age-related macular degeneration, predictive models using the genetic results enable fairly accurate prognosis of individuals who are at high risk of disease (Seddon et al. 2008), (iv) Wnt signaling through the



Linkage disequilibrium (LD) is a measure of the correlation between alleles at two sites in a sample of chromosomes. For two biallelic sites, if the A1 allele is always paired with the B1 allele, and the A2 allele is always on the same haplotype as the B2 allele, then the two sites are said to be in perfect LD. Successive recombination diminishes LD. Interrogating one site for disease association allows investigators to indirectly interrogate other sites in sufficiently high LD with the interrogated site.

The most commonly used measure of LD in a sample of chromosomes is

$$r^2 = \frac{[freq(A_1B_1) - freq(A_1)freq(B_1)]^2}{freq(A_1)freq(B_1)freq(A_2)freq(B_2)}$$

Fig. 4.36 The concept of linkage disequilibrium

transcription factor *TCF7L2* plays a role in type 2 diabetes (Grant et al. 2006), and (v) aberrant IL-7 signaling likely contributes to multiple sclerosis susceptibility (Gregory et al. 2007).

The plot shows the tremendous progress in genotyping technology where, a decade ago, very little of the genome was accessible for disease studies using association designs through the current wave of viable sequencing-based whole exome studies (2010–2011) and whole genome studies (2012–2013). In Fig. 4.37, the average distance between adjacent genetic markers is plotted as a function of year of introduction to the disease mapping community. Impressively, the total number of genetic markers has increased a million-fold over the past decade.

Although successful in uncovering numerous pathogenic pathways for common diseases, results from the current wave of genome-wide association studies, with a few exceptions, explain little of existing disease heritability. The reasons for this are cryptic and the subject of heavy debate (Manolio et al. 2009). Multiple rare sequence variants generating high levels of allelic heterogeneity, functional *de novo* mutations, structural mutations such as copy number variants and large deletions, and epigenetic effects constitute four of several possible disease models that could account for the heritability discrepancy. The answer will almost certainly consist of a conglomeration of these and other effects. Bringing forth the new genome-wide technologies that illuminate these previously non- or under-interrogated properties of the genome to bear on this enigma is a reasonable next step for all complex traits including oral diseases.

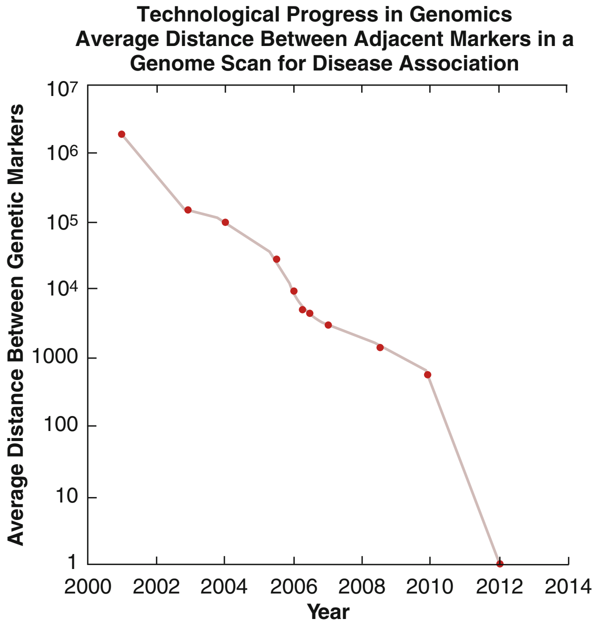


Fig. 4.37 Technological progress in genomics

4.6.3.3 Structural Variants, Rare Variants, De Novo Mutations, and the Site Frequency Spectrum

A key feature explicitly studied in molecular population genetics and implicitly used in disease gene mapping studies is the site frequency spectrum; that is, the distribution of allele frequencies at single sites in the genome that vary in the human population studied. From both diffusion models (Kimura 1970) and coalescent theory (Hudson 1991) in theoretical population genetics, we know that the vast majority of realistic models generate many more rare variants compared to common polymorphisms. This is particularly true for expanding populations. Are these rare variants the source of much of the missing heritability? Recently, with the application of high-throughput sequencing technology to human studies over the past decade, empirical studies have clearly verified these predictions – the large majority of variants have low frequencies (The International HapMap 3 Consortium 2010). The distribution of deletions appears to be skewed toward more rare frequencies, presumably due to the deleterious effects of such variants. Individual mutations appearing *de novo* typically are extremely rare events per locus, but collectively are numerous. Other types of genetic variability, such as copy number repeats, span both ends of the frequency spectrum with the preponderance of the markers being rare. Thus, there is a sizable pool of low-frequency variants in human populations that have yet to be thoroughly investigated.

Over the past few years it has become increasingly clear that structural variants exist in the human genome at a far higher rate than previously thought. Structural variants can exist in a multitude of forms including deletions, copy number variants, and inversions among others. Due to the nature of these genetic changes, many are considered to be highly disruptive of molecular function if they lie in functional motifs. Indeed, there are several Mendelian diseases are caused by fully-penetrant structural variants impacting a chromosomal region (Lupski 2007). Numerous structural variants have recently been reported to be associated with common diseases, particularly in the neurological field (Sebat et al. 2007; Stefansson et al. 2008; Elia et al. 2010), infectious disease susceptibility (Gonzalez et al. 2005), and drug metabolism (Zackrisson et al. 2010). Although they have improved dramatically over the past few years, algorithms using SNP-based data from hybridization arrays to infer copy number variants have had high error rates, perhaps explaining the rather low rates of replication of structural variation association results for common diseases. Nevertheless, given the high frequency of structural variants, their pathogenic potential, and that we are on the precipice of a sequencing revolution in genome-wide studies, examination of these variants should be a high priority for new sequencing-based studies in oral disease susceptibility, progression, and related pharmacogenetic applications.

As different technologies examine different portions of the site frequency spectrum (i.e. genome-wide SNP scans interrogate variation that is common in the HapMap populations, whereas sequencing-based studies typically interrogate the entire frequency spectrum), where one believes genetic causation is harbored should influence the selection of genotyping technology. If common genetic variation contains the vast majority of heritable effects on disease phenotypes, then an investigator would be wise to employ a SNP-based experimental design. If, however, there is reason to believe that a significant portion of the genetic load of the disease studied exists in the highly populated portion of the distribution – the rare variants – then a sequencing-based study may be better suited to unravel causative alleles.

4.6.3.4 Epigenetics

The studies of heritability discussed previously show that there is heritable variation underlying a substantial portion of the variance observed in oral diseases. As discussed above, sequencing technologies may address many aspects of DNA variation including copy number loci, rare haplotypes, inversions, and insertions/deletions, but it is also worthwhile to repeat that the molecular mechanisms for disease heritability are not necessarily limited to variation at the DNA level. For a disease state, the covariance between relatives could be driven by co-inherited chromosomal regions or other phenomena. Chief alternative heritable mechanisms include DNA methylation (Hammoud et al. 2009), modifications to the histones (Bestor 2000), complex RNA zygotic transfer (Rassoulzadegan et al. 2006), and vertical transmission of infectious agents. Additionally, transgenerational effects offer an intriguing class of epigenetic mechanisms (Nadeau 2009). In a thorough review on epigenetics and periodontitis, Gomez et al. make a strong argument for consideration of both CpG dinucleotide methylation and deacetylation actions on cytokine expression as a credible avenue for further investigation in periodontal disease etiology (Gomez et al. 2009). Genome-wide epigenetic studies have been successfully conducted for oral cancers (Poage et al. 2010). The scale of this study on head and neck squamous cell carcinomas allowed these researchers to show a global pattern of tumor copy number changes significantly correlated with methylation profiles that was not detectable at the individual gene promoter level. With advanced chromatin immunoprecipitation and new methods to study DNA methylation, efforts to apply high-throughput epigenetic methods to oral diseases should be accelerated.

4.6.4 Genetics of Oral Diseases

4.6.4.1 Candidate Gene Studies

Numerous studies have been conducted in oral disease traits using a candidate gene approach. There are two large reviews of the existing candidate gene results (Nikolopoulos et al. 2008; Laine et al. 2010). Laine and colleagues have recently put together a comprehensive review article covering gene polymorphisms. There are some suggestive findings for cyclooxygenase-2 gene, *COX-2*, the cytokine-encoding genes, *IL6* and *IL1B*, the vitamin D receptor, *VDR*, a polymorphism immediately upstream of *CD14*, and the matrix metalloproteinase-1 gene, *MMP1*. However, these initial results will require further confirmation, for the association patterns are inconsistent across independent studies, the statistical significance is moderate, and the posterior probability of disease is decidedly bland. The striking pattern that emerges from the Laine et al. summary data is the lack of coherent replication of genetic association for the vast majority of polymorphisms examined. The situation is reminiscent of genetic association studies prior to large-scale SNP studies where poor repeatability of results plagued the field. In a pivotal study from 2002, Hirschhorn and colleagues (Hirschhorn et al. 2002) examined the state of genetic association studies, finding that "of the 166 putative associations that had been studied three or more times, only six have been consistently replicated." The dearth of robust results was largely remedied when large-scale genetic studies were applied to very substantial numbers of well-characterized patients and genetically-matched controls and stringent statistical criteria enforced. One can only suspect that a similar state of affairs is operating in genetic studies of chronic periodontitis. Perhaps efforts to (1) reduce the heterogeneity of the disease state through detailed clinical and laboratory assessments, (2) drastically increase sample sizes, and (3) expand the scope of inquiry to larger numbers of genes/regions, and examine a more comprehensive set of variants/epigenetic effects will improve the current situation.

The second large study is a meta-analysis of 53 studies, where Nikolopoulos and colleagues analyzed six cytokine polymorphisms linked to *IL1A*, *IL1B*, *IL6*, and TNF-alpha (Nikolopoulos et al. 2008). Two of these, an upstream SNP in *IL1A* and a SNP in *IL1B*, exhibited significant association with chronic periodontal disease risk. Although the results were not particularly strong, as is typical with complex diseases, the results do suggest the importance of inflammation-response variability in chronic periodontitis predisposition.

Perhaps the strongest, most replicable genetic association finding with coronary heart disease and myocardial infarction is centered on the short arm of chromosome 9 (9p21.3) (McPherson et al. 2007; Helgadottir et al. 2007). Two studies of periodontal disease showed that the same alleles at the 9p21.3 locus confer risk for aggressive periodontitis (Schaefer et al. 2009; Ernst et al. 2010). The discovery of such a pleiotropic locus may explain a portion of the aggregation of periodontal disease with other co-morbid conditions. Further studies investigating overlapping genetic susceptibility factors between periodontitis and cardiovascular disease, diabetes mellitus, metabolic syndrome, rheumatoid arthritis, and other related diseases may be a fruitful strategy for honing in on shared genes affecting these immuno-metabolic disorders.

4.6.4.2 Linkage Studies

Using patients from 46 families from the Philippines, the first genome-wide linkage study for caries was completed in 2008 (Vieira et al. 2008). The study identified five loci which exhibit suggestive statistical evidence (LOD scores exceeding 2.0): 5q13.3, 14q11.2, Xq27.1, 13q31.1, and 14q24.3. The latter of which overlapped with a quantitative trait locus discovered from mapping work in the mouse. Further work is necessary to refine these signals and localize the variants that may be driving these linkage signals.

Aggressive periodontal disease and rarer dental diseases have also been subjected to linkage analysis. Results from linkage studies for dentinogenesis imperfecta type I, for example, have gone on to produce the novel gene findings of the dentin sialophosphoprotein-encoding gene on 4q21.3 being responsible (Song et al. 2008; Crosby et al. 1995). A linkage study in African American families examining localized aggressive periodontitis found a strong linkage signal in a region covering approximately 26 megabases on chromosome 1 (Li et al. 2004). Several interesting genes are in this region. In a study earlier this year further mapping from Carvalho et al. in Brazilian families identified haplotypes in this region on 1q in *FAM5C* which were associated with aggressive periodontitis (Carvalho et al. 2010). The function of the FAM5C protein is not fully understood. FAM5C is localized in the mitochondria and it appears to play a role in vascular plaque dynamics and risk of myocardial infarction (Laass et al. 1997).

It should also be noted here that other types of mapping analyses such as homozygosity mapping to identify have yielded gene discoveries. For example, the lysosomal protease cathepsin C gene for the recessively-inherited Papillon-Lefevre syndrome which is characterized by aggressive and progressive periodontitis was effectively mapped using homozygosity mapping (Fischer et al. 1997; Connelly et al. 2008). Cathepsin C is highly expressed in leukocytes and macrophages and is a key coordinating molecule in natural killer cells (Rao et al. 1997; Meade et al. 2006). Although sparse, these linkage results are undoubtedly encouraging. Employing very large extended families subjected to genome-wide genotyping or sequencing will surely shed much needed light on chromosomal regions and genes relevant to oral disease research (Fig. 4.38).

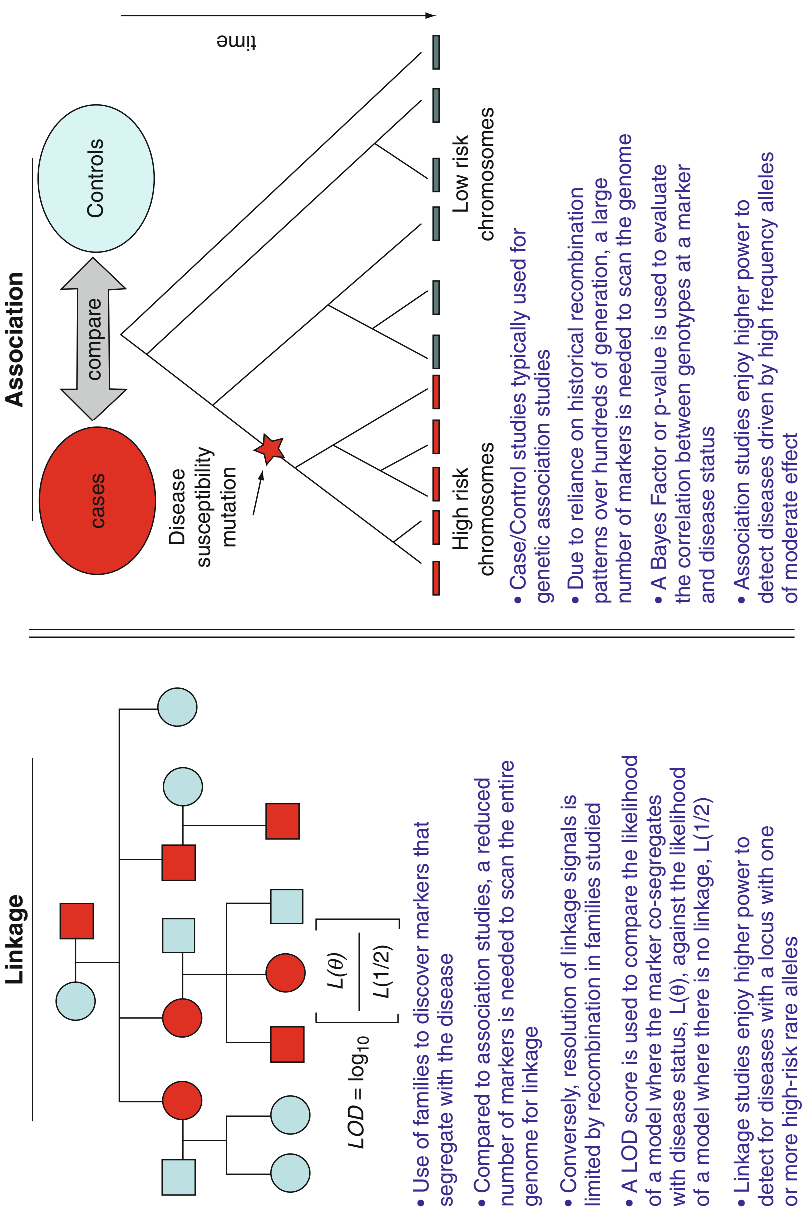


Fig. 4.38 Linkage studies vs. association studies to discover disease genes

4.6.4.3 Genome-Wide Association Studies

For periodontitis, a single study has employed a genome-wide association design in an effort to uncover aggressive periodontal variants (Schaefer et al. 2010). This study by Schaefer and colleagues discovered and replicated an intronic SNP, rs1537415, in the glycosyltransferase *GLT6D1* which is significantly correlated with aggressive periodontal disease in both German and Dutch samples. Often, seemingly significant results from large studies are due to the effect of reporting the top result from a great many statistical tests – this is called the multiple testing problem. In this situation, the strength of the finding, along with the replication across three case/control studies, argues for true association with aggressive periodontal susceptibility. The SNP may modulate the binding affinity of GATA-3. The association with *GLT6D1* is currently one of strongest genetic associations for aggressive periodontal disease, testifying to the power of genome-wide studies to generate novel, relevant molecular pathophysiology for complex diseases. It seems unlikely that *GLT6D1* would be extremely high on a candidate gene list, and it was only through a genome-wide scan that it appeared. Like many excellent studies, the finding by Schaefer et al. raises more questions than it answers and will undoubtedly provide fertile ground for ensuing molecular work.

4.6.5 The Future of Oral Disease Genetics

After a somewhat sluggish start, due to a lack of critical mass of investigators aiming to collect large numbers of patient samples and bring high throughput genetic technologies to caries susceptibility, gingivitis, and periodontal disease traits, the future of genetic studies in oral health is bright. Scientific progress in revealing the molecular pathogenesis of oral diseases is dependent on genome-wide genetic studies; and I have argued that progress in related immuno-metabolic diseases is also dependent on these large-scale genetic studies in periodontal disease. To study sporadic disease, substantial patient collection efforts are required for the application of these technologies. This may involve a combination of new recruitment and consortium-relationships with existing collections. The beginning of such a collection for sporadic aggressive periodontitis in Europe has shown extremely intriguing initial results, but more patients are needed to examine rare variants of moderate effect. Both the German/Dutch collection of aggressive periodontitis and the Brazilian collection have begun to revolutionize the study of periodontal disease susceptibility with the discovery of *GLT6D1* SNPs and *FAM5C*-linked haplotypes. There is little doubt that subsequent molecular work on these two genes will uncover novel mechanisms for the predisposition to aggressive periodontal disease. Focus should also be placed on the collection of extended families segregating these diseases. Applying sequencing technologies to large pedigrees can be an effective method of identifying rare variants and structural variants in a highly-refined phenotype. Furthermore, applying these methods to the entire genome would make for a comprehensive genetic study.

Several trends in large-scale genomics science hold promise to significantly advance our understanding of oral disease pathogenesis:

- The sociology of biological sciences has changed over the past 15 years so as to become more collaborative. Essential for association-based designs, consortium-based genetic research has blossomed over that time period, increasing sample sizes and therefore the power to detect disease-causing variants. There currently is consortium-based research in periodontal disease and oral cancer. Further expanding these efforts will enhance subsequent studies, particularly those investigating rare alleles and/or rare epigenetic effects.
- Through over a century of laboratory work, the collective knowledge of biochemical pathways, signal transduction, cell physiology, regulatory mechanisms, and structural biochemistry is weighty. Incorporation of this information into etiological models may substantially advance oral disease work as well as the field of complex disease genetics in general. Sophisticated analysis techniques are needed to perform this task. Recent advances merging results from network science with probability theory within the context of computer science have produced the field of machine learning. This rigorous framework can be used to identify those factors responsible for disease status and can also be used to develop robust predictive models using known biological networks and genetic data. The output from such models, typically the probability of disease, an estimate of disease progression rate, or a probability of adverse reaction, can be used by physicians and dentists to personalize medical care.
- Until relatively recently, population genetics did not contribute a great deal to human genetics research. That has changed in the past decade where effort spent on association studies surpassed that spent on family-based studies. Those investigating disease gene mapping began to collaborate with population geneticists and population geneticists took up a wide-spread interest in finding disease alleles. Incorporation of population genetics theory into such studies markedly improved association studies on several levels: confounding by population stratification was effectively treated using population genetics, linkage disequilibrium patterns. Use of population genetics theory in large-scale oral disease mapping studies may accelerate discoveries.
- Sequencing technology has rapidly progressed over the past decade. Currently, sequencing studies across the exome can be accomplished at reasonable cost and yield data for all known genes in the genome. Within the next few years, sequencing costs will depreciate to a point where whole-genome sequencing studies will be commonplace, using both family-based and population designs. Application of these technologies to oral disease studies is imperative for comprehensive studies of etiology.
- High-throughput DNA methylation and chromatin immunoprecipitation studies will enable large-scale epigenetic studies in oral diseases (Meade et al. 2006; Ehrich et al. 2005; Bibikova et al. 2006; Ren et al. 2000; Pokholok et al. 2005). These have already started to play an important role in delineating mechanisms responsible for oral cancers (Poage et al. 2010). Additional application of these techniques to studies of gingivitis, caries, and periodontal diseases may generate novel findings.

- Molecular biologists and pharmacologists have increasingly become able to develop and evaluate highly targeted pharmaceuticals based on genetic discoveries. The use of such genetic information may improve the chances of developing efficacious therapies.
- Geneticists and disease researchers are beginning to realize that oral diseases both impact and are intrinsically tied to susceptibility and progression of other common diseases. A synthesis of genetic findings from immuno-metabolic-linked disorders would seem to greatly increase the knowledge of these diseases and better pinpoint their respective etiologies.
- As the new high-throughput genomics and epigenomics technologies become implemented in oral disease research, the storage, management, analysis, and interpretation of the ensuing colossal amounts of data will be critical to enable clinicians to use these results in daily practice. Advances in dental and medical informatics will facilitate these steps.

We are in exciting times where advances in genetic technologies will uncover the genetic causes of diseases, including those that affect the oral cavity. With more focus in the area of oral disease genomics and the harnessing of new high-throughput sequencing and epigenetic technologies, novel insights into the pathways driving these diseases are imminent. These discoveries will, in turn, motivate directed therapies, aid in illuminating the molecular etiology of related disorders such as diabetes, and increase the level of personalized medicine.

4.7 Education – When You Come to a Fork in the Road, Take It

Joseph Kilsdonk

4.7.1 Introduction

The title of this section reinforces a 1995 Institute of Medicine (IOM) report titled "Dental Education: at the Crossroads." To quote Yogi Berra, a baseball sage: "When you come to a fork in the road, take it." The implication being that dental education must take action and move beyond its crossroads. These crossroads are described in the first third of the section. It includes a summary and recommendations of the IOM report and three transitional reports that followed: the 2000 Surgeon General's report identifying oral health as a silent epidemic, the Josiah Macy Foundation report, and a "Pipeline" study funded by both the Robert Wood Johnson and the California foundations. Having been at the crossroads for a decade or so, the middle portion of the section highlights educational models that may lead to a more promising future. The later third of this section describes an alternative path of action for dental education which emphasizes the central roles of clinic-based education and dental informatics in dental education curriculum. It is unknown how traditional dental educators may view this model; however, it is effectively a logical conclusion and responsive to the reports.

4.7.2 Where We Were

In 1995 the Institute of Medicine (IOM) published "Dental Education at the Crossroads" (Field 1995). The title was apropos as the authors' analysis concluded: (1) economics surrounding dental education were unsustainable ; (2) student service learning opportunities and access to care for patients were limited; and (3) new dental schools were not replacing those forced to close due to the economic climate. The IOM report additionally proposed key recommendations to reform dental education and service delivery. Fifteen years later, we remain at "the crossroads" as these issues remain largely unresolved. Furthermore, these recommendations have retained their validity. Their implementation would directly impact structures and services for contemporary models of dental education in the future.

The following IOM recommendations (Field 1995) are intrinsic to the proposed dental education reform:

> *Recommendation 2*: To increase access to care and improve the oral health status of underserved populations…
> *Recommendation 3*: To improve the availability of dental care in underserved areas and to limit the negative effects of high student debt…
> *Recommendation 5*: To prepare future practitioners for more medically based modes of oral health care and more medically complicated patients, dental educators should work with their colleagues in medical schools and academic health centers to:

- Move toward integrated basic science education for dental and medical students;
- Require and provide for dental students at least one rotation, clerkship or equivalent experience in relevant areas of medicine and offer opportunities for additional elective experience in hospitals, nursing homes, ambulatory care clinics and other settings;
- Continue and expand experiments with combined MD-DDS programs and similar programs for interested students and residents;
- Increase the experience of dental faculty in clinical medicine so that they, and not just physicians, can impart medical knowledge to dental students and serve as role models for them.

> *Recommendation 6*: To prepare students and faculty for an environment that will demand increasing efficiency, accountability, and evidence of effectiveness, the

committee recommends that dental students and faculty participate in efficiently managed clinics and faculty practices in which the following occurs:

- Patient-centered, comprehensive care is the norm;
- Patients' preferences and their social, economic, and emotional circumstances are sensitively considered;
- Teamwork and cost-effective use of well-trained allied dental personnel are stressed;
- Evaluations of practice patterns and of the outcomes of care guide actions to improve both the quality and the efficiency of such care;
- General dentists serve as role models in the appropriate treatment and referral of patients needing advanced therapies;
- Larger numbers of patients, including those with more diverse characteristics and clinical problems, are served.

Recommendation 17: Because no single financing strategy exists, the committee recommends that dental schools individually and, when appropriate collectively evaluate and implement a mix of actions to reduce costs and increase revenues. Potential strategies, each of which needs to be guided by solid financial information and projections as well as educational and other considerations, include the following:

- Increasing the productivity, quality, efficiency, and profitability of faculty practice plans, student clinics, and other patient care activities;
- Pursuing financial support at the federal, state, and local levels for patient-centered predoctoral and postdoctoral dental education, including adequate reimbursement of services for Medicaid and indigent populations and contractual or other arrangements for states without dental schools to support the education of some of their students in states with dental schools;
- Rethinking basic models of dental education and experimenting with less costly alternatives;
- Raising tuition for in or out-of-state students if current tuition and fees are low compared to similar schools;
- Developing high-quality, competitive research and continuing education programs;
- Consolidating or merging courses, departments, programs, and even entire schools.

In summary, the IOM report identified that: (1) an outdated curriculum continues to be retained which reflects past dental practice rather than current and emerging practice and knowledge; (2) clinical education does not sufficiently incorporate the goal of comprehensive care, with instruction focusing too heavily on procedures; (3) medical care and dentistry are not integrated; and (4) the curriculum is crowded with redundant material, often taught in disciplinary silos.

The 1995 IOM's Report was followed by the Surgeon General's Report on Oral Health in 2000 and a subsequent supplement by the Surgeon General in 2003 called "The National Call to Action" (U.S. Department of Health and Human Services

2003). Five significant findings and recommendations from the Surgeon General's Report(s) that have implications pertaining to the envisioned structure and services of new models for dental education include:

- Changing the perception of oral health so that it will no longer be considered separate from general health;
- Improving oral health care delivery by reducing disparities associated with populations whose access to dental treatment is compromised by poverty, limited education or language skills, geographic isolation, age, gender, disability, or an existing medical condition;
- Encouraging oral health research, expanding preventive and early detection programs, and facilitating the transfer of knowledge about them to the general population;
- Increasing oral health workforce diversity, capacity, and flexibility to overcome the underrepresentation of specific racial and ethnic groups in the dental profession. In this regard, the National Call to Action urged the development of dental school recruitment programs to correct these disparities and to encourage part-time dental service in community clinics in areas of oral health shortage;
- Increasing collaboration between the private sector and the public sector to create the kind of cross-disciplinary, culturally sensitive, community-based, and community-wide efforts to expand initiatives for oral health promotion and dental disease prevention.

Spurred by the 1995 IOM report and the 2000 Surgeon General's report, the Josiah Macy Foundation (2004) conducted a study entitled "New Models of Dental Education." The study was prompted by concerns about declines in dental school budgets and the difficulties experienced by schools in meeting their educational, research, and service missions. The Macy study concluded that:

- Financial problems of dental schools are real and certain to increase.
- Current responses of schools to these economic challenges are not adequate.
- Most promising solutions require new models of clinical dental education.

Macy study lead researcher Dr Howard Bailit, and his team recently concluded in reference to points one and two above, that: "If current trends (to aforementioned) continue for the next 10 years, there is little doubt that the term *crisis* will describe the situation faced by dental schools. Further, assuming that it will take at least ten or even more years to address and resolve these financial problems, now is the time for dental educators, practitioners, and other interested parties from the private and public sectors to come to a consensus on how to deal with the coming crisis. Clearly, these financial problems will not be solved by minor adjustments to the curriculum, modest improvements in the clinical productivity of students or faculty, or even significant increases in contributions from alumni. The solutions 'must involve basic structural changes in the way dental education is financed and organized' (Bailit et al. 2008)." This statement is supported by the fact that in the past 25 years more dental schools have closed than opened. Specifically eight schools have closed, whereas to date a couple has opened and a handful is pending.

Curriculum relevance was also a focus of the study. Findings concluded that "changing the curriculums in dental schools to allow students to spend more time in community venues would be highly beneficial to both society and student. Society benefited from having underserved patients cared for while students were assessed as being five to ten times more productive, more proficient, more confident, more technically skilled and more competent in treating and interacting with minority patients" (Brodeur 2008).

Macy study (Formicola et al. 2005) outcomes represented significant and foundational guideposts for assessing and planning any future models for dental education. Their report led to the Robert Wood Johnson Foundation Pipeline Study (2007), a major research study funded by the Robert Wood Johnson Foundation and The California Endowment (TCE). The goal of the Dental Pipeline Program was to reduce disparities in access to dental care. The Pipeline study provided over $30 million for the start up or expansion of 15 schools and student clinical programs that incorporated services to underserved extramural clinical settings (primarily community health centers).

- The following recommendations from the Surgeon General's report structured the goals of the Pipeline's initiative: Increase the number of under-represented minority and low-income students enrolled in the dental schools participating in the Pipeline Program so that there would be a voice of minority and low-income students at all the funded schools.
- Provide dental students with courses and clinical experience that would prepare them for treating disadvantaged patients in community sites.
- Have senior dental students spend an average of 60 days in community clinics and practices treating underserved patients. Increasing the community experience of dental students was expected to have an immediate impact on increasing care to underserved patients (Brodeur 2008). This third point is pivotal to future success of dental curricula and dental education economics.

Recently published in a supplemental volume to the *Journal of Dental Education*, February, 2009, the Pipeline study reported the following outcomes:

- Minority recruitment of low-income students increased by 27%;
- The rate of recruitment for under-represented populations was almost twice that of non-pipeline schools;
- The length of time dental students spent in extramural rotations increased from a mean of 16 days to a mean of 39 days over a period of 4 years.
- Procedural proficiency increased compared to that of their non-extramural peers.
- Of the 15 Pipeline-funded programs, only four schools achieved the goal of 60 days of extramural rotations; Through extra funding from TCE, the four schools extended extramural rotations to an average of 198 days;
- Based on this publication, it appears that only a handful of pipeline schools definitely plan to sustain their extended extramural rotations. Financial concerns were highlighted as the major problem in sustaining future recruitment and placement of students beyond the timeframe of the study;

- A survey of program seniors indicated a mean of 26% [range of 14–60% by school] were planning to devote ≥ 25% of their practice to serving minority patients. Only 9% [range of 3–22% by school] were planning to practice at community clinics.

In the context of these outcomes, discussion indicated that the unwillingness of students to practice in underserved settings was based on several factors:

- Students that participated were already enrolled in traditional programs and were not necessarily seeking a pipeline experience or a future in community service.
- Concern over future reimbursement as a provider in a community setting;
- Limited time spent in underserved settings;
- Limited loan forgiveness scholarship opportunities.

The fact that the large majority of pipelines were unsustainable was attributed to lack of productivity in the school clinics while the students were on rotation at community based clinics. Schools generate meager, yet necessary revenue streams on intramural student clinical activity to support the costly clinical and faculty infrastructure. Currently, similar economic constraints involved with outsourcing students to serving rural and underserved populations impacts the ability of tradition dental schools to participate in sustained outreach programs.

Most recently, the Pew Center on the States National Academy for Health Policy (2009) released "Help Wanted: A Policy Makers Guide to New Dental Providers". This report provided an excellent summary outlining workforce needs, access issues, and strategies for dental-related services to help states and institutions develop creative ways to solve oral health access and care issues. The Guide proposes the following relevant components and trends for consideration in development of future sustainable school models:

- Dental colleges are willing to bear a large and disproportionate share of the burden in terms of access to care, particularly during a time of incredibly scarce resources.
- Expanded, extensive, and/or creative extramural rotations have been developed in recent years under the conceptual umbrella of service-learning. These often involve clinics providing direct or indirect payment to dental schools or clinics managed in some way by dental schools.

4.7.3 Where We Are: Economics, Equity, and Education Converge

Dental education has certain obligations. First, education must adhere to accreditation standards with the goal of producing competent practitioners. Second, education must remain responsive and impact the societal need for care. Lastly, the delivery of dental education must be economically sustainable. The Macy, RWJF, and IOM reports note that improved oral health, sustainable dental education economic models, and competent workforce pipelines converge around Community Health Centers (CHC). University of Michigan researchers Fitzgerald and

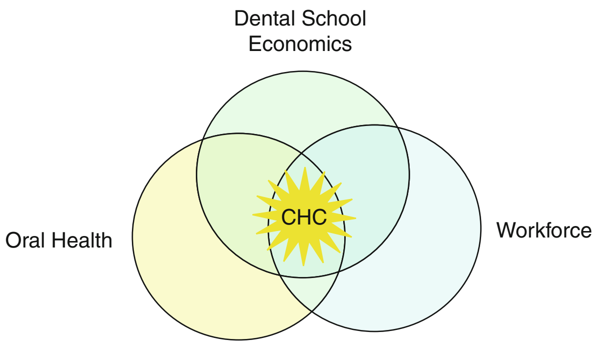


Fig. 4.39 The synergy between access to care, student competency, and financially sustainable dental education converge around CHC/FQHCs

Piskorowski (2009) reaffirm this conclusion in an evaluation of an ongoing 7-year program, stating that:

> (the CHC model) is self-sustaining and can be used to increase service to the underserved and increase the value of students' clinical educational experiences without requiring grant or school funding, thus improving the value of dental education without increased cost. Self-sustaining contracts with seven Federally Qualified Health Centers (FQHCs) have resulted in win-win-win-win outcomes: win for the underserved communities, which experienced increased access to care; win for the FQHCs, which experienced increased and more consistent productivity; win for the students, who increased their clinical skills and broadened their experience base; and win for the school in the form of predictable and continuing full coverage of all program costs (Fitzgerald and Piskorowski 2009) (Fig. 4.39).

However, unlike medicine that outsources their students to clinical sites, dental education programs retain the majority of the student time within their own "clinical laboratories" As documented by the aforementioned studies, this limits students' exposure to extramural experiences. Costs to operate such intramural clinical programs are ever increasing and many schools' clinical operations run deficits. If that component can be outsourced to community-based resources such as a CHC, then the burden of cost is shifted away from the school.

An example would be A.T. Still University's Arizona School of Dentistry and Oral Health (ASDOH) which matriculated its first class in 2003. At the prompting of the State's community based clinics, ASDOH designed a program that placed students into community-based settings for up to 6 months, an unprecedented length of time for an extramural rotation. They also saw this as an opportunity to use an adjunct centric faculty that significantly reduced traditional education overhead. Through this innovation, the school was able to develop a program that was sustained by "fair market" value tuition and trained students where community needs were greatest for up to 6 months (which was then unprecedented). Conversely, if the CHC can rely on student service-learning to care for patients, the cost of care is reduced.

Other schools are also advancing with innovative education and care delivery. ADEA's Charting Progress (Valachovic 2009) identified several schools that are in planning stages and two in progress. They include Western University in Pomona, California; East Carolina University in North Carolina; Midwestern University in Glendale, Arizona; University of New England in Portland, Maine; Texas Tech University Health Sciences Center in El Paso, Texas; the University of Arkansas in

Little Rock, Arkansas; and the University of Southern Nevada in South Jordan, Utah. Western University is planning placement of 50% of their fourth year class in community health centers, while East Carolina is seeking to set up rural clinical campuses as well as clinical partnerships with the State's FQHC. At the time of this publication, several existing schools are expanding or looking to expand including the University of North Carolina, Marquette University, Midwestern University in Downer's Grove, IL. Such expansions will contribute to solving the existent access supply and demand issues. However, it was observed even with all the start ups and expansions, graduation numbers will not approach the output of schools in the late 1970s and early 1980s.

These creative models establish the foundation for a sustainable clinic structure by generating self-sustaining revenue through student service-learning, which, unlike medical student services, are billable. Simultaneously these new models provide access to care for the needy while student exposure to clinical experiences that are often not available in academic patient pools. These models also shift some of the cost of providing clinical education from the dental college to community-based clinics.

However, this innovation is not without criticism. Schools are dependent on the success of their clinics and clinic partnerships. One author cautions: "However, these creative models also may present potential political strategic risk or conflict: private practitioners may organize and protest higher than normal reimbursement schemes. Potentially, such protests could even jeopardize the very existence of such models (Dunning et al. 2009)." Notably, community health centers have historically received strong bipartisan support. For example, during the Bush administration, FQHC funding was doubled and most recently expanded through health reform legislation by the Obama administration.

4.7.4 A Road to the Future

According to the Institute for Oral Health, "The group practice of the future is the dentist working with the physician" (Ryan 2007). The ADA reported "multidisciplinary education must become the norm and represent the meaning and purposes of primary care as it applies to dentistry. Educational sequences should include rotation strategies across discipline specialties in medicine and dentistry, clerkships and hospital rotations, and experience in faculty and residency clinics." (Barnett and Brown 2000) The models alluded to, were school-based attempts at improving educational outcomes. Perhaps the proverbial fork in the road regarding the future of dental education leaves two paths for consideration. Is it better to travel down a road that leads a school to develop and operate a clinic? Or is the road less traveled, where a clinic becomes a school, the better of the two options? The answer, perhaps, is that a combination of both will accomplish the desired outcome. For example, didactic knowledge is measured by examination whereas competency as a practitioner is measured by clinical demonstration. At a minimum, the result must achieve learner competency, quality, and sustainability. However, the road less traveled has not been taken yet. William Gies, in his revered report written 85 years ago on the state of American dental education, wrote “Dental faculties should show the need…. for integrated instruction in the general principles of clinical dentistry and in its correlations with clinical medicine” (Gies 1926). Basic sciences aside, could a clinical-based educational training center have an advantage over a school-based clinical center? Soon-to-be-implemented new Commission on Dental Accreditation (CODA) standards will require schools to demonstrate competency in patient-centered care (Valachovic 2010). Might an enterprise proficient at running a successful clinical business model have an advantage running a professional, patient-centered clinical training program as compared to a pedagogical business model attempting to run a clinical training model? These questions should challenge us to reexamine why our thinking about educational models should be limited to schools being the starting point for the development of a profession that demands clinical competency, patient-centeredness, and integration as outcomes. The clinic based model may serve as an equivalent starting point and, have some distinct advantages for achieving responsiveness to recommendations and directions cited in this section.

4.7.5 A FQHC Model

Beginning in November 2002 through August 2010, the Family Health Center (FHC) of Marshfield, Inc, Marshfield, Wisconsin, launched of a broad network of developing dental clinics, targeting dental professional shortage areas with the provision of dental services to the underserved communities whose dental needs were not being adequately met by the existing infrastructure. FHC-Marshfield is a Federally Qualified Health Center (FQHC). As an FQHC, FHC receives cost-based reimbursement for its dental services to Medicaid populations. Along with the cost- based reimbursement, FQHCs are obligated to provide care to anyone regardless of their ability to pay. Presently, FHC is the nation’s largest federally qualified dental health center. To date, this network of dental clinics has served over 58,000 unique patients, 85% of whom were under 200% of poverty. Notably, service was provided to a significant number of cognitively and developmentally disabled patients in special stations developed for serving patients with special needs. These patients frequently travel the furthest to get to our dental centers for care. Beginning in 2008, FHC stepped up the pace of dental clinic expansion, constructing two new dental centers in 2009, two in 2010, and two more are slated to open in 2011. When fully operational, this will establish capacity to serve 66,000 patients annually. Each site has proactively included dedicated clinical and classroom training space for dental residents or students, thus laying the framework for clinic-based training of new dental professionals. The plan is to continue to stand up new dental centers until they have the capacity to serve 158,000 patients annually or approximately 50% of the 300,000 underserved patients in the rural service area. In addition to the capacity for training residents and students, a dental post-baccalaureate program is being considered in partnership with regional 4 year under graduate campuses. The post-baccalaureate program is aimed at preparing students from rural and underserved areas who desire to practice in rural and underserved areas for acceptance and success in dental schools.

Presently FHC in partnership with Marshfield Clinic is moving forward with plans to develop dental residencies at these sites and a dental post baccalaureate training program to better prepare pre-doctoral students from rural and/or underserved backgrounds to be successful in dental school as a means to create a dental academic infrastructure responsive to rural environments which have been classically underserved. Marshfield Clinic has a long-standing history in medical student education and multiple medical residency programs.

4.7.6 Train Where the Need Is

Creating access for the underserved population was the major motivational force driving the establishment of the dental clinic network back in 2002. The findings of the IOM, Macy, and RWJF reports became the foundational framework for developing the vision of a dental education model that would realize the major recommendations found in the reports. By establishing clinical campuses in regional underserved dental health professional shortage areas, access to care where care is needed most was provided. Sustainment of a work force for provision of care across the dental clinic network is accomplished by schools contracting with FQHC's for service learning, thus circumventing challenges associated with releasing dental students at traditional dental schools to distant extramural training sites as discussed previously. This model is however not without its own set of challenges including calibration of faculty, supervision and evaluation of students in training, and achieving accreditation acceptance. However, through video connectivity and iEHR technology curriculum, learning plans, competency assessment, progression, performance, faculty development, and learner evaluations can be centrally calibrated. Additionally, this dental service-learning model based in a community health center setting offers students unique state-of-the-art exposures to alternative access models, cutting-edge informatics (including access to a combined dental-medical record) and a quality-based outcomes-driven practice.

Given the novelty of such an extended extramural dental clinical training model, there is limited data on the success of rural placement leading to retention to practice in a rural setting. The Pipeline study piloted a model for getting students into underserved communities. However, that experiment was limited to 60-day rotations. Outcome driven programs may provide a predictive surrogate for purposes of comparative analysis. For example, the Rural Medical Education "RMED" program of the University of Illinois medical school at Rockford, has sustained a longstanding program in Illinois. Over 17 years in duration with over 200 student participants of whom 70% have been retained as primary care medicine practitioners in rural Illinois. Rabinowitz et al. (2008a) further reinforced that medical school rural programs have been highly successful in increasing the supply of rural physicians, with an average of 53–64% of graduates choosing to practice in rural areas. They also noted rural retention rates of 79–87% among the programs (Rabinowitz et al. 2008a).

Recently, the University of Wisconsin School of Medicine and Public Health (UWSMPH) launched the Wisconsin Academy for Rural Medicine (WARM program). The WARM program places medical students in rural academic medical centers during their third and fourth years in medical school. Marshfield Clinic is one of those sites. WARM students affiliating with Marshfield Clinic's system would ultimately share learning experiences with dental students, clinical rotations, team-based rounding, lectures, and exposure to a combined medical-dental patient record. In an analogous manner, the Marshfield Clinic dental education model will incorporate a curriculum that embeds students in rural clinical practice for up to 2 years.

A secondary but not insignificant outcome of placing residents and students in clinical campuses focused on developing competency and providing care where needs are often greatest is the cost savings to taxpayers associated with the public care of patients. These savings are accomplished through the "service-learning" of the student. For example, in the model described where clinical training is embedded within the FHC clinics, the stipend resident or unpaid student learner provides the patient care as part of their service learning training while requiring oversight from one paid faculty per four to six learners. As a result, an academic based clinical partnership creates a model that reduces the cost for care provided to underserved patients. An additional benefit to the community based clinic might be realized through tuition assistance by the academic program to help support patient procedures that develop learner competencies.

> In educational quality and influence, dental schools should equal medical schools, for their responsibilities are similar and their tasks analogous (William Gies 1926).

The Commission on Dental Accreditation (CODA) notes that one of the learning objectives of an Advanced Education General Dentistry (AEGD) Residency is to have the graduate function as a "primary care provider". To function competently in this role, the graduate needs to have a strong academic linkage to primary care medicine. At a 2010 dental deans forum, 84 years after the Gies report, Dr Polverini made the statement "Dentistry has never been linked to the medical network but unless dentistry becomes part of the solution to the challenge of providing comprehensive patient care, it will be looked on as part of the problem, and ultimately, all dental schools will be called into question." (Polverini 2010) The use of dental informatics and an integrated record are elements essential to this competency. On April 1, 2010, FHC and Marshfield Clinic successfully transitioned all of their dental centers to a new practice management and electronic health record system that fully integrates medical and dental; one of the first such systems in the nation. Along with the benefits derived in Fig. 4.39, CHC placement also exposes students to an integrated medical-dental care setting where learners can develop skills in system-based practice to include the interdependence of health professionals, systems, and the coordination of care. On the administrative side, dental and medical appointments can be coordinated to enhance convenience for patients and improve compliance with preventive dental visits. In 2009, Marshfield Clinic's Research Foundation Biomedical Informatics Research Center hired their first Dental Informatician, Dr. Amit Acharya, BDS, MS, PhD. With dedicated biomedical informatics and research resource centers, the Marshfield Clinic has laid the groundwork for true medical/dental integration with appropriate electronic health record decision support and is positioned to develop a dental education curriculum capable of implementing the IOM recommendations. Downstream benefits of using such a curriculum are the ability of future practitioners to use informatics to improve quality of care and reduce the burden of disease.

According to an Institute of Oral Health Report (2010) it is widely accepted across the dental profession that oral health has a direct impact on systemic health, and increasingly, medical and dental care providers are building to bridge relationships to create treatment solutions. As early as 1926, William Gies recognized that "the frequency of periodic examination gives dentists exceptional opportunity to note early signs of many types of illnesses outside the domain of dentistry" (Gies 1926). The following examples show how integration of dental and medical care can impact patient outcomes, underlining the importance of this concept in dental curriculum design.

A 2009 study of 21,000 Blue Cross Blue Shield of Michigan (BCBS) members with diabetes, who had access to dental care lead researchers, and BCBS executives to conclude that treatment of periodontal disease significantly impacts outcomes related to diabetes care and related costs (Blue Cross Blue Shield of Michigan 2009). Another example is found in the context of preterm delivery and miscarriage. According to research cited by CIGNA (2006), expecting mothers with chronic periodontal disease during the second trimester are seven times more likely to deliver preterm (before 37th week), and have dramatically more healthcare challenges throughout their life. CIGNA also cites the correlation between periodontal disease and low birth weights, pre-eclampsia, gestational diabetes.

Equally important is the opportunity to develop and implement the team-based curriculum that trains future dentists and physicians in the management of chronic disease as an Accountable Care Organization (ACO) in a patient-centered environment. As an example, Joseph Errante, D.D.S., Vice President, Blue Cross Blue Shield of MA, reported that medical costs for diabetics who accessed dental care for prevention and periodontal services were significantly lower than those who didn't get dental care (Errante 2007).

These data suggest that team based case management of prevalent chronic health conditions have considerable cost savings opportunities for government payers, third party payers, employers and employees (Errante 2007). These economic benefits to integration as it relates to the iEHR are discussed elsewhere in this book, but begin with the ability of providers to function in a team based environment and as such, underscore the importance of training in such an environment.

Dentists trained in a FQHC iEHR integrated educational model will be well positioned to function successfully within an ACO model. An ACO is a system where providers are accountable for the outcomes and expenditures of the insured population of patients they serve. The providers within the system are charged with collectively improving care around cost and quality targets set by the payor.

Within this system, care must be delivered in a patient-centered environment. The patient-centered environment according to the National Committee for Quality Assurance (NCQA), is a health care setting that cultivates partnerships between individual patients and their personal physicians and, when appropriate, the patient's family. Care is facilitated by registries, information technology, health information exchange and other means to assure that patients receive defined, timely and appropriate care while remaining cognizant of cultural, linguistic and literacy needs of the patient being served. The model includes the opportunity to deliver patient care that is patient-centric, incorporates the patient in the care planning, considers the patient's beliefs and views, and incorporates the patient's families as needed. The model allows providers to deliver care that is inclusive of needs, attentive, and accessible. The model equips payers to purchase high quality and coordinated care among teams of providers across healthcare settings. While this describes the medical home, most dental practices also follow this process. Many dental practices function in this regard with insured populations and reflect elements of the model that medicine is creating. William Gies would be proud.

Training in the delivery of accountable and patient-centered medical–dental care must be done purposefully. Commenting on the inadequate training relative to the integration of medical and dental education, Baum (2007) stated that "we need to design new curricula with meaningful core competencies for the next generation of dentists rather than apply patches to our existing ones." While this statement was made in reference to the basic sciences, the same holds true for patient-centered system-based practice competencies. Utilizing state-of-the-art electronic medical records as a tool and the FHC infrastructure as the service venue, meaningful patient-centered system-based practice core competencies achievement becomes possible in a manner highly responsive to societal needs. By definition, FQHCs must provide primary medical care, dental care, and behavioral health. FQHC have also historically been utilized as healthcare workforce training centers and the Affordable Care Act of 2010 reinforced their role as healthcare training centers. Specifically, this legislation serves to promote FQHCs as the entity through which the primary care workforce (including dental) will be developed and expanded. In combination, FQHCs and primary care centers are positioned to be the front runners in a medical/-dental home training model which will be essential to preparing future practitioners for practice in an ACO. Critical to this success is the ability to train these practitioners on an integrated medical-dental record and informatics platform. Use of this platform imprints most strongly during the learner's formative years of training; instructing and guiding disease management, decision making, patient care coordination, prevention, and both outcome-based and comprehensive care. Training in this hybrid academically orientated clinically integrated setting moves dental education off its crossroads and creates the highway to its future.

4.7.7 Concerns

Concerns with the new models extend to their ability to integrate medical and dental disciplines at the clinical and informatics level. While the 1995 IOM report identified the need to integrate medical and dental curriculum, success at the curricular and technological level within schools, has been limited. Three major factors have contributed to the limited progress:

- Access priorities. Creating access to care has outranked the need to integrate care. In part, this reflects societal need for care and public demand to reduce the burden of the "silent epidemic." Schools play an important role as a safety net to care for the uninsured and underinsured through intramural clinical service learning. Even though "dental colleges seem to be willing to bearing a large and disproportionate share of the burden in terms of access to care" (Dunning et al. 2009), schools were challenged as part of IOM, Surgeon General, and Macy reports, to expand that role. While these reports have prompted creative educational solutions to increase access, the reports understate the tremendous opportunity, quality and cost benefits that could result from an integration of medicine and dentistry.
- It is difficult to change the culture and structure of existing schools. This is not unique to dentistry. However, the 1995 IOM report specifically recommended that schools "eliminate marginally useful and redundant courses and design an integrated basic and clinical science curriculum". The challenges with this are many. Examples include:
  - Some schools may not have other disciplines to draw from to create an integrated curriculum;
  - A number of schools use a faculty senate to determine curriculum. This can result in curriculum that preserves the current faculty structure;
  - Changing curriculum is associated with expense and can be financially prohibitive to some schools
  - Physical changes may be needed and represent an expense and/or may, in some instances, may not be practicable based on structure of existing facilities.
  - Public school programs may direct the final curriculum, as boards or regent's one or two steps removed from the curriculum often have final authority conversely, private schools may specify business or mission objectives that determine final design.
- Perhaps most germane to this text is the lack of a common technology platform between disciplines in a learning environment. An integrated curriculum requires an integrated platform to accomplish delivery and evaluation. This is particularly essential to clinical management of the patient by professionals in training as part of a healthcare delivery team. Some progress in establishing shared basic sciences curricula has been documented in the literature. To date, no single integrated electronic health (medical-dental) record has been meaningfully adapted for educational purposes, including incorporation of assessment of the learner relative to integrated competencies, integrated case-based and problem-based curriculum, and integrated evaluation and assessment.

Another concern with new educational programs emerging in response to these reports and relative to creating a transformational integrated curriculum is that some of the programs are focusing primarily on creating clinicians with no value or emphasis on integrating training with research and/or scholarly activity. Integrated training models counter such concerns. Research will be fundamental to measuring the relative benefits and outcomes associated with treatment of patients in a shared curriculum setting and will be the catalyst for the development of integrated medical-dental informatics incorporating educational capabilities.

Additionally, accreditation will also need to evaluate its response to such models. Presently it is unclear how accrediting bodies will view an integrated cross-disciplinary curriculum. Further, due to its integrated nature, such a curriculum would lie outside of the expertise of a single traditional accrediting body focused on one particular discipline. It has yet to be determined how accrediting bodies will review and appraise such cross-disciplinary competencies.

Lastly, it is important to recognize that a successful education model with innovative informatics is only successful if its focus is patient care. Graduating learners with competency only in the use of informatics will be limited unless adapted to training and delivery programs that result in patient centric care.

4.7.8 Conclusions

Research and reports over the past 15 years support the need to reform dental education. First steps have been taken and lead the way for continued innovation around clinic-based education and integrated curriculum. The models identified point to a strong partnership and interrelationship with CHCs for creative, cost saving, effective and sustainable delivery methods. Moreover, CHC's must be more involved in a training curriculum integrated with informatics. CHCs, in turn, benefit from residents and students through service-learning to help meet a societal and workforce need, while the learners benefit from increased competency. In order to train an evidence-based, patient-centered, medical-dental workforce, it is imperative that medical and dental data and record accessibility be incorporated into these training and care delivery initiatives. In order to keep moving away from the crossroads, such integration must become the pathway on which curriculum is developed and implemented.

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