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Diphtheria and Australian Public Health: Bacteriology and Its Complex Applications, *c.* 1890–1930

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During the 1890s, the childhood infectious disease of diphtheria became closely identified with the emerging science of bacteriology and the new laboratory-based public health.[1] Along with the organisms causing typhoid fever and tuberculosis, the Klebs-Loeffler bacillus was one of the earliest to be clearly isolated (in 1883) and causally linked to disease. Compared with other illnesses, such as scarlet fever, diphtheria had a clear bacteriological presence and an apparently simple mode of action, and, despite ongoing debate over the laboratory data in the 1880s and 1890s, many physicians and public health officials saw possibilities for engineered intervention into its spread and progress. Particularly after the widely-publicized failure of tuberculin in the early 1890s, and the success of antitoxin therapy for diphtheria from 1894, the management of diphtheria came to stand for new bacteriological modes of infectious disease control and prevention. For example, in 1896 a contributor to the *Journal of State Medicine* wrote: "Preventive Medicine has become more and more lost in Bacteriology. To many a micro-organism is all-sufficient; they would summarily dispose of Diphtheria in three simple steps—examine all mouths, find Klebs-Loeffler bacillus, isolate the subject".[2] Similarly, in Australian

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[1] This point is made in Evelynn Hammonds' recent exploration of diphtheria in New York, where much of the research into its bacteriology was carried out in the late 1880s and 1890s. Evelynn Hammonds, *Childhood's deadly scourge: the campaign to control diphtheria in New York City, 1880–1930*, Baltimore, Johns Hopkins University Press, 1999. Historical literature on diphtheria is otherwise fairly sparse in comparison with other infectious diseases. See Anne Hardy, *Epidemic streets: infectious disease and the rise of preventive medicine, 1856–1900*, Oxford, Clarendon Press, 1993, pp. 81–109; Jane Lewis, 'The prevention of diphtheria in Canada and Britain 1914–1945', *J. Soc. Hist.*, 1986, **20**: 163–76; Catherine Braithwaite, Peter Keating and Sandi Viger, 'The problem of diphtheria in the province of Quebec: 1894–1909', *Soc. Hist.*, 1996, **29**: 71–95.

[2] Anon., 'Diphtheria and elementary schools', *J. State Med.*, 1896, **4**: 245, cited in Anne Hardy, 'On the cusp: epidemiology and bacteriology at the Local Government Board, 1890–1905', *Med. Hist.*, 1998, **42**: 328–46, on p. 329.

medical literature, articles about bacteriology were frequently articles about diphtheria, and *vice versa*.[3] As Evelynn Hammonds has demonstrated, diphtheria is ideally placed for thinking through the historical connections between bacteriology and applied public health precisely because it was so strongly associated with laboratory medicine and the new capacities to understand and therefore control disease. Yet the new practices of diphtheria control themselves posed continual challenges to bacteriology: diphtheria and the emerging bacteriological sciences were mutually constitutive. In this article we closely analyse the application of bacteriological knowledge and techniques as public health practice through the lens of diphtheria in Australia. We trace shifts in policy from the 1890s when the antitoxin was first used as treatment, to the late 1920s when immunization against diphtheria represented the first mass immunization campaigns in Australia.

Over the past fifteen years or so, the historiography of germ theories and their intersection with public health has introduced subtleties that earlier histories lacked. While the received history suggested that bacteriology rationalized diagnosis, exposed cause and thus made possible effective public health measures,[4] we now have increasingly elaborate understanding of the complexity of the discipline itself: the ways in which concepts of immunity altered;[5] how epidemiologists sometimes clashed, and sometimes came together fruitfully with increasing numbers of specialists identifying themselves as "bacteriologists",[6] how Kochian and Pasteurian programmes had different implications in the field of public health;[7] how bacteriological concepts of disease played out in, and were partly shaped by, colonial encounters.[8] With

[3] For example, 'Bacteriology and public health', *Aust. med. J.*, 1890, **12**: 519–20; A Jefferis Turner, 'The place of bacteriology in practical medicine', *Australas. med. Gaz.*, 1895, **14**: 200–6.

[4] For example, Charles Edward Amory Winslow, *The conquest of epidemic disease: a chapter in the history of ideas*, Madison and London, University of Wisconsin Press, 1980; a classic Australian version is J H L Cumpston, *Health and disease in Australia: a history*, ed. Milton Lewis, Canberra, Australian Government Printing Service, 1989; H J Parish, *Victory with vaccines: the story of immunization*, Edinburgh, E and S Livingstone, 1968. See discussion of this issue in Andrew Cunningham, 'Transforming plague', in Andrew Cunningham and Perry Williams (eds), *The laboratory revolution in medicine*, Cambridge University Press, 1992, pp. 219–44; Bruno Latour, *The Pasteurization of France*, Cambridge, MA, Harvard University Press, 1988.

[5] Arthur M Silverstein, *A history of immunology*, San Diego, Academic Press, 1989; *idem*, 'The dynamics of conceptual change in twentieth century immunology', *Cell. Immunol.*, 1991, **132**: 515–31; W F Bynum, *Science and the practice of medicine in the nineteenth century*, Cambridge University Press, 1994, pp. 158–64; Pauline M H Mazumdar, *Species and specificity: an interpretation of the history of immunology*, Cambridge and New York, Cambridge University Press, 1995.

[6] Hardy, op. cit., note 2 above, pp. 328–9; C E Gordon Smith and Mary James Throstle, 'Early work in anthropology and epidemiology: from social medicine to germ theory, 1840–1920', in Craig R Janes, Ron Stall, Sandra M Gifford (eds), *Anthropology and epidemiology: interdisciplinary approaches to the study of health and disease*, Reidel, Dordrecht, 1986, pp. 35–57.

[7] See Paul Weindling, 'Scientific elites and laboratory organisation in *fin de siècle* Paris and Berlin: the Pasteur Institute and Robert Koch's Institute for Infectious Diseases compared', in Cunningham and Williams (eds), op. cit., note 4 above, pp. 170–88; K Codell Carter, 'The Koch–Pasteur dispute on establishing the cause of anthrax', *Bull. Hist. Med.*, 1988, **62**: 42–57; Latour, op. cit., note 4 above.

[8] For example, Mark Harrison and Michael Worboys, 'A disease of civilisation: tuberculosis in Britain, Africa and India, 1900–1939', in Lara Marks and Michael Worboys (eds), *Migrants, minorities, and health: historical and contemporary studies*, London and New York, Routledge, 1997, pp. 93–124; Warwick Anderson, 'Immunities of empire: race, disease and the new tropical medicine 1900–1920,' *Bull. Hist. Med.*, 1996, **70**:

respect to diphtheria, Hammonds has provided a comprehensive account of how public health instrumentalities and bacteriology each shaped concepts and strategies in the other.[9] Part of this rethinking has attempted to render this historiography not general, but local and specific. In a recent special issue of *Journal of the History of Medicine and Allied Sciences*, editors and contributors have analysed the reception of germ theories in different national and colonial sites.[10] Mary Sutphen, for example, has tempered the significance of germ theories in and of themselves with the question of their application as plague prevention measures. She argues that in colonial Hong Kong and Calcutta at the very end of the nineteenth century, debate "centred not on germ theories but on what actions to take against the plague . . . bacteriology and germ theories did not narrow the range of methods to control the disease". Argument raged "not over what the plague bacilli were, but over *where* they were to be found".[11] She writes that rather than germ theories offering new paradigms for public health, longstanding sites and methods of disease control were continued or reinstigated. Along with the contributors to that issue, we are convinced of the need to study the intellectual and social histories not only of particular places, but of particular infectious diseases.

In this article we use the case study of diphtheria in Australia as a way of exploring the complexities and the unexpected turns of bacteriologically-informed applied public health. We are interested in the "reinvention" of diphtheria as a result of its bacteriological understanding, in the way that Andrew Cunningham has explored the production of the plague by laboratory medicine.[12] More precisely, we are concerned with the complicated public health events that succeeded the laboratory studies of the late nineteenth century. Even though bacteriology was clearly crucial for the redefinition of diseases, this process was ongoing, and we demonstrate that there were no *necessary* applications of the new understandings of infectious diseases in public health practice. In Australia, as Hammonds argues of New York, once diphtheria came to be understood in bacteriological terms, a range of often contradictory public health policies and practices were pursued in quick succession. These successive public health measures in turn shaped the ongoing bacteriological understanding of diphtheria and of infectious disease control. From the instigation of "vaccination treatments" and notification requirements in the 1890s, public health policy shifted very quickly to mass swabbing campaigns between 1916 and 1922, in

94–118; David Arnold, *Colonizing the body: state medicine and epidemic disease in nineteenth-century India*, Berkeley, University of California Press, 1993.

[9] Hammonds, op. cit., note 1 above.

[10] Nancy Tomes and John Harley Warner, 'Introduction to special issue on rethinking the reception of the germ theory of disease: comparative perspectives', *J. Hist. Med. Allied Sci.*, 1997, **52**: 7–17. See also Ilana Löwy, 'Yellow fever in Rio de Janeiro and the Pasteur Institute mission (1901–1905)', *Med. Hist.*, 1990, **34**: 144–63.

[11] Mary P Sutphen, 'Not what, but where: bubonic plague and the reception of germ theories in Hong Kong and Calcutta, 1894–1897', *J. Hist. Med. Allied Sci.*, 1997, **52**: 81–114, on pp. 111–12.

[12] Hammonds, op. cit., note 1 above; Cunningham, op. cit., note 4 above.

which "carriers" were the prime, almost exclusive, consideration.[13] From 1922 onward, observation of the failure of these campaigns became the basis of an official policy towards mass immunization, though its piecemeal implementation meant that immunization only gradually superseded carrier control and cleansing practices as the major preventive measure. Each of these policies were outcomes of bacteriological knowledge and techniques, but represented vastly different perceptions and practices of prevention. There was nothing automatic about the implications of bacteriology, especially given ongoing discussion of technical issues within it. There was nothing predictable about the way it played out as applied public health, nor was there any immediate connection between the availability of certain techniques (immunization, for example) and their application as public health measures. While the new laboratory sciences seemed to solve some diagnostic and therapeutic difficulties at the time, and have been classically analysed historically as having done so, it is rather more profitable (not to mention accurate) to trace how bacteriology also produced a new set of problems.

Diphtheria management played a critical role in the development of Australian public health institutions and policies. Historians have variously analysed smallpox, scarlet fever, typhoid, tuberculosis and plague as diseases of cultural and political importance in the shaping of public health in the nineteenth-century British colonies and in the Commonwealth of Australia, established in 1901.[14] However, the childhood disease of diphtheria has lacked the attention we believe it warrants.[15] Expressed statistically, socially and politically, diphtheria had a high profile in the late nineteenth and early twentieth centuries. In this period it was a serious and relatively uncontrolled epidemic illness and in the early decades of the twentieth century was one of the greatest causes of childhood mortality in Australia, as in many other countries.[16] But we suggest that the specific and close connection between bacteriology and diphtheria rendered it an especially significant disease. In Australia, diphtheria was a primary locus for local physicians to work through ideas developed in laboratories elsewhere.[17] Over this period, diphtheria was reconceptualized from being a treatable disease on an individual basis but not really a preventable one, to being thought of

[13] For a detailed study of the concept of the healthy carrier in the American context, see Judith Walzer Leavitt, '"Typhoid Mary" fights back: bacteriological theory and practices in early twentieth-century public health', *Isis*, 1992, **83**: 608–29; *idem*, *Typhoid Mary: captive to the public's health*, Boston, Beacon Press, 1996.

[14] Cumpston, op. cit., note 4 above; Robin Walker, 'The struggle against pulmonary tuberculosis in Australia, 1788–1950', *Aust. hist. Stud.*, 1983, **20**: 439–61; T J Brain, 'Some notes on the history of smallpox in Tasmania, 1803–1988', *Aust. Microbiol.*, 1988, **9**: 361–64; R G Kellaway, 'The Hobart typhoid epidemic of 1887–88', *Soc. Sci. Med.*, 1989, **29**: 953–58; Peter Curson and Kevin McCracken, *Plague in Sydney: the anatomy of an epidemic*, Sydney, University of New South Wales Press, 1989; F B Smith, 'The investigation of plague in Australia', in Linda Bryder (ed.), *New countries and old medicine*, Auckland, Pyramid Press, 1994, pp. 32–8; Alison Bashford, 'Epidemic and governmentality: smallpox in Sydney, 1881', *Crit. Publ. Health*, 1999, **9**: 301–16.

[15] But see F B Smith, 'Comprehending diphtheria', *Health and History*, 1999, **1**: 138–61, which discusses the medical politics surrounding a Royal Commission of Inquiry into Diphtheria held by the Victorian government in 1872.

[16] K Hallam, 'Diphtheria prophylaxis in private practice', and *idem*, 'Diphtheria in Victoria', *Health Bull.*, 1927, **11**: 348–9, 350–4.

[17] The research carried out in New York laboratories was crucial here. See Hammonds, op. cit., note 1 above, especially chs 2 and 3.

as a manageable problem of the population, even a disease which might be eradicated totally. This reconceptualization was a major impetus in the formation of many early Australian public health strategies. It was the new imperative to diagnose diphtheria bacteriologically which largely produced the pressure for government-funded laboratories; it was in reference to diphtheria that the concept of the healthy "carrier" first appeared in Australian medical circles, and as the locus of major campaigns of swabbing and isolation; it was in the management of diphtheria that Australian governments first tackled large-scale and long-term preventive measures, most importantly the first mass immunization campaigns; and it was diphtheria-control which integrated public education structures with public health structures, school medical services with measures for infectious disease control. That diphtheria was a disease of children—a population already defined and managed by government in various ways—is crucial in understanding its significance in shaping Australian public health.

Certain peculiarities of geography and government are important to a comparative understanding of public health in the Australian colonies and in the subsequent Commonwealth. The sparse population there meant that the natural histories of diseases were often different to European patterns, that certain diseases never became endemic, and that "herd immunities" were difficult to achieve in immunization campaigns. As an island-continent all kinds of diseases endemic in Europe were not introduced until colonization in the late eighteenth century. Moreover, the distance between Europe and Australia (and, it must be said, highly effective quarantine measures) resulted in a cholera-free continent. Over the nineteenth and early twentieth centuries there was an obsessive concern amongst Australian public health, quarantine and immigration officials about the comparative time between a sea-voyage from Europe, the Middle-East, India or America and the incubation period of various infectious diseases, cholera especially. Internally, the vast distances between urban and rural communities, indigenous and non-indigenous, logistically hampered many public health campaigns. For example, the chances of persuading a rural mother to travel hundreds of miles to have her child vaccinated, and then return on the seventh day for the vaccine scar to be checked, to do so for all her children, and to have each revaccinated, were minimal to say the least.

Important to the development of public health in Australia is the legacy of highly governed society left largely by British penal colonization: governments always had a greater direct involvement in welfare, in public hospitals, in health education, than government in Britain. This centralized government along with a strong labour political tradition meant that a concern for public health was successfully integrated into turn-of-the-century models of state responsibility for "welfare". While many other western nations were also experimenting with welfarist states at this time (with major implications for the bureaucracy, policy and practice of public health) it is peculiar to Australian history that this occurred simultaneously with explicit political and social discussion of nationalism, citizenship and alternative government structures; for in 1901, the six British colonies became the self-governing Commonwealth of Australia. As a result, three tiers of government were created: Commonwealth, State (the old colonies) and local government. "Health" powers were to remain with

the state governments, although the Commonwealth was responsible for large-scale infection control and quarantine measures, which soon expanded into responsibility for vaccine production and regulation.[18] In practice, most public health measures, including the classic "sanitarian" reforms such as sewering and garbage disposal, were vested in local government. It is significant for diphtheria that this reorganization (and massive growth) of government responsibility occurred precisely when public health itself was being rethought within bacteriology. Much of the infrastructure of public health was implemented with respect to the management and prevention of diphtheria.

Applications of Bacteriology in the 1890s

As is now well known, before 1880 diphtheria presented difficulties in diagnosis because of its varied clinical manifestations. It was first described in the 1820s by Pierre Bretonneau, who identified it as a form of croup with a classic clinical feature, the growth of a thick membrane across the throat, from which the name "diphtheria" (from the Greek) originated.[19] However, the term came into general use only when it was applied to what appeared as a horrifying new epidemic disease which spread globally in 1858.[20] Its novelty and terror gave it a prominent profile in popular culture during the frequent epidemic outbreaks.[21] Although lay and medical constituencies reacted to "diphtheria" as to a new disease, its identity was far from certain. Controversy over how to classify and treat diphtheria structured European, American and Australian medical debate from this early period. Diphtheritic patients could present with a wide range of symptoms, and in a significant minority, the definitive symptom—the membrane in the throat—did not develop. There was in fact neither a stable clinical picture of "diphtheria", nor a definable categorical distinction between it and certain other diseases, such as croup and scarlet fever.[22] Before 1883 (the year the diphtheria bacillus was isolated by both Edwin Klebs and Friedrich Loeffler), diphtheria presented serious problems of variation, which precluded the identification of public health measures to combat it.

Thinking of diphtheria as croup, or *not* as croup, made certain assumptions about its symptoms, social context, and progress through the population—in other words, about public health. "Croup" implied familiarity and inevitability; "diphtheria" implied a new public scourge. There were concomitant shifts in expectations for treatment: if diphtheria was "really" croup, then cases ought to be treated in the

[18] For the importance of public health and quarantine measures in the expression of a racist Australian nationalism at this time, see Alison Bashford, 'Quarantine and the imagining of the Australian nation', *Health*, 1998, **2**: 387–402.

[19] J H L Cumpston, *The history of diphtheria, scarlet fever, measles and whooping cough in Australia, 1788–1925*, Canberra, Government Printer, 1927, p. 8.

[20] Ibid., p. 16; Hardy, op. cit, note 1 above, p. 81.

[21] Hammonds, op. cit., note 1 above; Hardy, op. cit., note 1 above, p. 82; Terra Ziporyn, *Disease in the popular American press: the case of diphtheria, typhoid fever and syphilis, 1870–1920*, New York and London, Greenwood Press, 1988.

[22] Hardy, op. cit., note 1 above, p. 81, notes that in Britain diphtheria was classed first with scarlet fever, then with cynanche maligna in the Register-General's returns; Cumpston, op. cit., note 19 above, devoted his first chapter to discussing identification.

established medical and social parameters for childhood endemic disease—in the home, and in private. There was little sense of *public* management of any individual case, as there was for diseases defined as "epidemic". Individual treatment consisted of the continued removal of the membrane as it formed in conjunction with scrubbing the throat and the inhalation of various purifying substances from carbolic acid to potash. Intubation and tracheotomy were not infrequent.[23]

Despite popular insistence that diphtheria was a public problem, and some government response to this,[24] diphtheria could not be taken up as a question of public health, according to Australian medical opinion of the era. This opinion was expressed in a Royal Commission of Inquiry into Diphtheria held in 1872, with physicians questioning how solutions could be found locally when research overseas had failed to discover any.[25] Diphtheria, croup and scarlet fever were generally distinguished and registered separately in mortality cases from 1859, but debate on whether such distinctions were justifiable continued through the 1860s and 1870s. Its epidemiology was entirely dubious as the result of its confusing clinical variation. Contravening contemporary ideas which located the origins of disease in polluted sites—cities, foetid air, foul water, pigsties, the impoverished and the immoral—diphtheria appeared everywhere. Instead, it was termed a "democratic" disease, one which spread among the rural, wealthy and hygienic as frequently as among the urban, poor and dirty.[26] The ongoing disquieting sense that diphtheria challenged existing frameworks for understanding illness maintained its profile in the medical and lay press. Diphtheria's significance lay partly in this challenge, and the resulting anxiety was expressed in Australia in vociferous denials from physicians that any sanitary, public hygiene or isolation measures could have a lasting ameliorating effect on the disease.

The advent of bacteriology transformed medical response to the disease by constructing an apparent certainty, proclaimed from the beginning despite ongoing discussion of aetiology.[27] The transparency which bacteriology gave to diphtheria's aetiology and mechanism in turn clarified the theory. Discussions of diphtheria were central to the evolving concepts of bacteriology as they were slowly worked through by colonial medical societies, by the few Australian medical scientists who came to identify themselves as "bacteriologists" in the late nineteenth century, and by British-educated, university-based physicians with access to laboratories as well as clinical practice. This was so much the case that during the 1890s, diphtheria and bacteriology were directly identified with each other.[28] However, the sense contemporaries had of

[23] Anne Hardy, 'Tracheotomy versus intubation: surgical intervention in diphtheria in Europe and the United States, 1825–1930', *Bull. Hist. Med.*, 1992, **66**: 536–59.

[24] Claire Hooker, 'Community and medicine: diphtheria management and public health in Australia, 1858–1895', *Occasional Papers in Medical History*, 1999, **9**; Smith, op. cit., note 15 above, pp. 138–61.

[25] Hooker, ibid.; Smith, op. cit, note 15 above, pp. 138–61.

[26] Hooker, ibid.

[27] The instantaneous faith placed in bacteriology by many scientists, physicians and public health officials despite a lack of closure on the scientific data has been commented on by many historians, including Latour (op. cit., note 4 above). Hammonds also notes the sense of certainty that prevailed in New York despite intellectual debate and professional controversy. Hammonds, op. cit., note 1 above, chs 2 and 3.

[28] See Jefferis Turner, op. cit., note 3 above, pp. 200–6; 'Bacteriology and public health', *Aust. med. J.*, 1890, **12**: 519–20.

an astonishing, revelatory, revolutionary transformation in thinking about the disease after 1883 was followed by several decades of a slow reconstruction in its conceptualization.

The bacteriological explanation of diphtheria rested on a few simple concepts that would become the basis for public health measures directed against infectious disease control. The bacillus for diphtheria seemed to be clearly identifiable, unlike, for example, the streptococci of scarlet fever. Locating this single cause of the illness solved the problem of differential diagnosis by providing an apparently incontrovertible method: diagnosis could be made only if bacteriological tests confirmed the presence of *B. diphtheri*. With a precise identity, diphtheria was located institutionally (through registration) in the realm of public health. The general confidence invested in bacterial diagnosis produced diphtheria as *the* fatal throat disease of early childhood. By the 1890s, bacteriological diagnosis had become so determinative that children with throat diseases who did not show the microbe were dismissed from hospitals—although some of these cases still proved to be fatal.[29]

However, the sense of diagnostic certainty initially offered by the discovery of the bacillus soon turned into a complicated set of new bacteriological, clinical and public health problems, the intellectual detail of which is discussed by Hammonds.[30] The anxious problem of variation was not solved by the discovery of the Klebs-Loeffler bacillus, but was displaced. The laboratory became the new site where medical uncertainty was investigated and managed. In Australia, alongside the periodic triumphant articles which focused on the success of bacteriology, others quickly proliferated concerning the variant forms of the bacilli, the difficulty of recognizing them, and the changing virulence and infectiousness of the disease. There was especial attention paid to other bacilli present in diphtheritic infections, recalling earlier fears of cross-identification between diphtheria and scarlet fever, another epidemic disease of particular concern in the colonies.[31] While these problems did not give rise to the conflicts between clinicians and bacteriologists that occurred in New York and in Britain, they did raise a series of practical problems for the management of the disease. The question arose of what to do with patients who did not fit a simple bacteriological classification: in what ward, for example, ought patients suffering from both scarlet fever and diphtheria to be placed?[32]

A second key concept particularly associated with diphtheria was that illness did not simply result from the local multiplication of the bacilli themselves but from the systemic debility and paralysis caused by a toxin excreted during that multiplication.

[29] J Ross, 'The so-called diphtheria epidemic in Warrnambool', *Australas. med. Gaz.*, 1892, **11**: 178–80; continued pp. 215–17; 244–52.

[30] Hammonds, op. cit., note 1 above, pp. 46–87.

[31] Cumpston, op. cit., note 19 above, pp. 7, 16–18; Jefferis Turner, note 3 above, pp. 200–6. Well into the twentieth century, Australian physician-researchers published articles detailing difficulties in classifying and defining diphtheria in bacteriological terms. These articles paralleled those published thirty years earlier in clinical terms, and continued to explicitly address the implications for public health response to the illness. See F V Scholes, 'Diphtheria and scarlet fever: present day problems', *Aust. med. Congress Trans.*, 1929: 26–30, which linked ongoing difficulties in the bacterial diagnosis of scarlet fever with variation in diphtheria, and linked both these difficulties with the problem that treatments for diphtheria had not improved for thirty years.

[32] C P Clubbe, 'On the diagnosis of diphtheria', *Australas. med. Gaz.*, 1895, **14**: 17–21.

This explained the conjunction of local and general symptoms during the illness, illuminated the mechanism of the bacilli, and soon provided the basis for a stunningly successful antitoxin serum treatment in Britain and Germany.[33] Antitoxin was enormously important in shaping laboratory-based public health institutions, in Australia and overseas. In New York, the treatment was used to establish and fund a research laboratory in the Division of Pathology, Bacteriology and Disinfection. The strategic "selling" of antitoxin, including public fundraising for antitoxin production, tended to limit debate on the treatment in both medical and lay forums.[34] "Antisera" were briefly produced for diseases ranging from tuberculosis to cancer. Some proved far less useful than others; attempts to find equally simple treatments for tuberculosis, typhoid fever and scarlet fever in the same period utterly failed. Nevertheless, antisera treatments and prophylactics would become highly profitable business early in the twentieth century.[35] Indeed, W F Bynum claims that diphtheria antitoxin was fundamental to the creation of the modern pharmaceutical industry (a view also subscribed to by opponents of its production).[36] In Australia the new treatment was taken up early, though relatively quietly, with medical journals periodically publishing reports of its efficacy.[37] In 1895 the New South Wales Agent-General in London was directed to dispatch a regular supply of antitoxin serum to the colonies.[38] The general consensus was that serum manufacture ought not to be attempted locally. Australian physicians were instead faced with evaluating different sources of antitoxin supply, all European, and with the dangers of administering horse blood that had undergone a long, hot voyage.

Treatment with antitoxin was referred to as "vaccination", indicating its method of administration. While the term remained strongly associated with smallpox prophylaxis, its use was now extended in the context of scientific medicine. Physicians increasingly referred to various "vaccine therapies" and discussed how to induce "autovaccination".[39] Vaccination was predicated on the evolving concept of immunity, the bacteriologically-defined capacity of a body to resist infection by the production of antitoxins and antigens. Vaccination provided those already diagnosed or symptomatic with a "passive", short-term immune boost. It was not employed as a prophylactic against the disease, although nursing staff on diphtheria wards were vaccinated as an ongoing protection from diphtheria. In the same decade, the use of genuinely prophylactic smallpox vaccination, which had been widely deployed fifty years earlier, declined to extremely low levels.[40] Thus developed the clear and

[33] Hardy, op. cit., note 1 above, pp. 102ff; Winslow, op. cit., note 4 above.

[34] Hammonds, op. cit., note 1 above, pp. 88–119.

[35] Wai Chen, 'The laboratory as business: Sir Almroth Wright's vaccine programme and the construction of penicillin', in Cunningham and Williams (eds), op. cit., note 4 above, pp. 209–45.

[36] Bynum, op. cit., note 5 above, p. 164. Objections were made largely by antivivisection groups who also criticized commercial interests in medical research (see, for example, a collection of such leaflets and pamphlets held at the Powerhouse Museum, Sydney 89/273–1–20).

[37] For example, L N Ashworth and A J Turner, 'The value of antitoxin in the treatment of diphtheria', *Aust. med. J.*, [new series] 1896, **1**: 561–77.

[38] Cumpston, op. cit., note 19 above, pp. 38–40.

[39] See, for example, D A Welsch, 'A contribution to a discussion on serum and vaccine', *Aust. med. Congress Trans.*, 1911, pp. 145–9.

[40] Cumpston, op. cit., note 4 above, pp. 189–90.

optimistic identification of diphtheria with a new form of public health which rested on the rational foundations of bacteriology. "Vaccination" in Australia was not merely regarded as a treatment, but as a profoundly important public health measure. The vastly lowered case mortality which immediately resulted was regarded as a public benefit in itself. Morbidity fell in Victoria from 92.11 per 100,000 in 1890 to 14.51 per 100,000 in 1900. In New South Wales in the same years it fell from 58.9 to 6.5 per 100,000.[41] "No child ought to die from diphtheria", Brisbane Children's Hospital physicians L N Ashworth and A J Turner had declared in 1896,[42] and in a lecture reminiscing about bacteriology titled 'Romance in medicine', Dr J C Verco stated explicitly that saving a child's life "to the State" made antitoxin serum treatment an important part of public health.[43] Physicians also thought that effective treatment would slow down the incidence of the disease, leading, perhaps, to its natural eradication. The Australian bacteriologist Dr Thomas Cherry forecast that "the proportion of such malignant cases will continually grow less. We are able to profoundly modify the germs of many diseases, by compelling them to grow upon unfavourable cultural media; and paucity of cases will mean that the bacilli will be unable to acquire increased virulence by rapid transference from throat to throat".[44]

The sense of triumph associated with bacteriology in its specific identification with diphtheria provided the rhetorical basis for the construction of a "modern", "scientific" public health infrastructure managed by State and Commonwealth governments at the turn of the century. Diphtheria diagnosis relied upon medical expertise supported by a custodial government, and the bacteriologist was vested with the combined powers of science and public health. Instead of competing for authority with clinicians or field epidemiologists,[45] the bacteriologist was quickly referred to as a specialist, but one also in possession of the full gamut of skills required for effective public health management. The bacteriologist remade clinical practice and epidemiology from the laboratory, wielding authority based precisely on the integration of medical knowledges. The editor of the *Australian Medical Journal* wrote in 1890 that "bacteriological investigations must play a very important part in all studies concerning the causation and mode of prevention of disease in general, and also in inquiries into particular outbreaks, must now be admitted by all . . . In addition to his special knowledge, the bacteriologist must know something of medicine, and still more of pathology. He must have considerable knowledge of sanitary science, and he must be an expert chemist".[46]

The bacteriological laboratory was now entirely necessary for diphtheria to be governmentally managed in the population through registration, notification, and

[41] Cumpston, op. cit., note 19 above, p. 102. This source has extensive compilations of diphtheria related statistics showing variation in mortality and morbidity between States and within States, by season, and by gender and age. These show that there was no significant difference in rural and urban incidence of the disease.

[42] Ashworth and Turner, op. cit., note 37 above.

[43] J C Verco, 'Romance in medicine', *Med. J. Australia*, 1918, i: 1–7.

[44] T Cherry, 'Diphtheria antitoxin', *Aust. med. J.*, 1895, **17**: 101–6.

[45] Cunningham, op. cit., note 4 above, pp. 238–9; Hardy, op. cit., note 2 above.

[46] 'Bacteriology and public health', *Aust. med. J.*, 1890, **12**: 519–20.

treatment: swabs needed to be cultured, identified and tested for virulence, imported antitoxin serum needed to be checked for strength and purity. Pleas were frequently made for the establishment of more government-run bacteriological laboratories.[47] In the late 1880s, the only self-identified bacteriologists in Australia were Dr Thomas Cherry, who was given space at the University of Melbourne, and a pupil of Koch, Oscar Katz, who was funded through the enthusiastic patronage of William Macleay.[48] However, by the early twentieth century laboratories were established at many hospitals.[49] For example, at the Sydney Children's Hospital a laboratory was built with a new "Diphtheria Cottage".[50] Importantly, each of the colonial governments developed their own government laboratory. These, however, were limited to the capital city, a centralization which would hamper public health strategies against diphtheria in Australia's far-flung rural regions.

Although the isolation of the Klebs-Loeffler bacillus did not lead a priori to an elucidation of diphtheria's aetiology (as they worked through evolving bacteriological concepts Australian practitioners argued *inter alia* that "bacilli" could be inhaled miasma-like from rotting carcases, or generated spontaneously in unhealthy bodies),[51] bacteriology nevertheless was imagined as the foundation for minutely controlling public health instrumentalities. Relatively securely diagnosed, diphtheria began to be mapped in terms of the community, rather than the individual patient. The microbe made the disease potentially visible at all points of its transmission. Already in the 1890s some in the medical profession fantasized a complex machinery of bacteriology which would perfectly monitor the disease. Dr Cherry wrote in early praise for antitoxin serum that "[i]n the city of New York, all sore throats are examined bacteriologically by the Department of Health. All cases must be notified like an infective disease, and by return of post a couple of tubes of serum and a swab for the throat are sent with instructions for making cultures from the throat. The tubes are returned to be incubated, and the bacteriological diagnosis made the following day."[52] The literal mapping of New York in terms of diphtheria prevalence which took place in the 1890s, with its concentration of attention and control on impoverished and immigrant neighbourhoods and the physical marking of infected houses was not, however, contemplated.[53]

This fantasy of perfect monitoring made possible by certain diagnosis required compulsory notification. Notification was coming to be regarded as the basis for all public health action, making disease officially visible and constructing a medical, legal, social and administrative arena for measures to be brought against it. The new enthusiasm for notification in the wake of bacteriology—diphtheria was made notifiable in NSW, South Australia and West Australia in 1898, and shortly thereafter

[47] Ross, op. cit., note 29 above; Clubbe, op. cit., note 32 above.

[48] Frank Fenner (ed.), *History of microbiology in Australia*, Canberra, Australian Society for Microbiology, 1990, pp. 6, 12.

[49] Exact details can be found in ibid., pp. 137–79.

[50] Clubbe, op. cit., note 32 above; Such laboratories often prepared diphtheria antitoxin before the foundation of the Commonwealth Serum Laboratories in 1916. See Fenner, op. cit., note 48 above, p. 147.

[51] J B Ross, 'On bacilluria of Roberts, with demonstration of pure cultures: preliminary notice', *Aust. med. J.*, 1890, **12**: 497–501.

[52] Cherry, op. cit., note 44 above, p. 104.

[53] Hammonds, op. cit, note 1 above, pp. 96–7.

in the rest of the country[54]—indicates that bacteriology initially was incorporated in an essentially local, "sanitary" (in the quasi-moral sense of "cleansing")[55] public health framework. Although notification did not prescribe compulsory action consequent to the outbreak of infectious disease, it implied that detailed, local knowledge of its presence would result in the co-ordinated response of all sectors of the specific community affected. Public health officials expected notification to render steps for control of the disease possible, to aid discovery of the source of infection, to help provide efficient treatment for it, to give local authorities direct information on the history of the disease, to educate the community about it, and to allow judgement of the most appropriate preventative measures.[56] To accomplish most of these aims, notification required the consensual and co-operative involvement of the families of the ill, the medical practitioner, the Medical Officer of Health and the local Council. In practice, measures to manage diphtheria varied enormously with individual officials from different local Councils, a problem faced in England as well.[57]

Bacteriological identity for diphtheria, and laboratory observation of its aetiology, reconfigured the spatial management of patients and their carers. Many patients continued to be treated in their homes, but hygienic practices around their care were strictly codified, from contact with other people to the regular disinfection of their clothes and bedding. Importantly, there was a noticeable shift to hospitalization as a matter of course in severe cases, although without the level of police control exercised in the tenement districts of New York.[58] In the 1890s many Australian public hospitals, like their counterparts in Britain and the US, established clearly demarcated diphtheria wards, as much to isolate the disease as to treat it.[59] The provision of public hospital space to manage diphtheria made hospitals the primary sites where contingent practical problems concerning the new concepts of infection and immunity were worked through. They became the institutional centrepiece of public health responses to diphtheria. While there were certainly smallpox isolation hospitals in Australia, the focus on diphtheria and public hospitals anticipated the general shift towards research, diagnosis and treatment of infections in these institutions, a significant component in the architecture of twentieth-century Australian public health.[60]

The separated diphtheria wards served several purposes: they allowed patients to be treated immediately, and, in the case of epidemic outbreak, en masse; the wards isolated diphtheria patients from others in the hospital to prevent the spread of the disease; and they allowed for early collection of what were regarded as the first

[54] Cumpston, op. cit., note 4 above, p. 398.

[55] For further discussion of the notion of sanitation as it shaped public health, see Claire Hooker, 'Sanitary failure and risk: Pasteurisation, immunisation and the logics of prevention', in Alison Bashford and Claire Hooker (eds), *Contagion: historical and cultural studies*, London, Routledge, 2001, pp. 129–52.

[56] T W Sinclair, 'General measures for the control of diphtheria, including legal control and disinfection', *Med. J. Australia*, 1924, i: 300–4.

[57] Cumpston, op. cit., note 4 above, p. 298, pp. 394–7; Lewis, op. cit., note 1 above.

[58] Hammonds, op. cit., note 1 above, pp. 79–80.

[59] Hardy, op. cit., note 1 above, p. 95.

[60] See Stanley Reiser, *Medicine and the reign of technology*, New York, Cambridge University Press, 1978, for a discussion of the rise of the laboratory in research and hospital situations.

reliable statistics on diphtheria, as all cases were bacteriologically diagnosed and managed. Hospitals, particularly those equipped with laboratories, continued to identify treatment with public health research and policy. For example, clinical trials of different antitoxin sera were undertaken in these hospitals. In an unusual preference for continental over British technology, Ruffer's, the brand manufactured by the British Institute of Preventative Medicine, and sent by the Agent General, was unfavourably compared with those coming from Pasteur's and Koch's laboratories.[61]

Hospitals also became the first site for a complex new mode of policing infection in the community, which would become widespread public health practice in the early twentieth century. Routine swabbing soon established that bacilli could be found in the throats of children who had apparently recovered, frequently for a month or longer. "Assuming it is one of the duties of a hospital to prevent the spread of infectious disease, it follows that no one can be discharged until the bacilli have disappeared from their throats", as Dr A J Turner of the Brisbane Children's Hospital put it.[62] Hospitals became the first node for the monitoring of such statistics—the statistics of bacilli—and for the control of carriers.

Tracking the Carrier

Between 1895 and 1920 there was an elaboration of public health instrumentalities aimed at detailed individual surveillance in the community, in an effort to control the incidence of diphtheria. Micro-controls monitoring individual behaviour and contacts, a set of rituals and rules for detailed bodily and spatial management, and large-scale governmental interventions were established. The promise of bacteriology was to make visible the specific paths of communication through which diphtheria moved around a community, potentially disruptable at any point. In particular, bacteriological research into diphtheria during the 1880s gave a newly certain meaning to the concept of "carrier": those who remained symptomatically healthy but whose bodies, carrying live bacteria, were infected and infecting. Tracking carriers was to become a major procedure for infectious disease control during the twentieth century—from typhoid to tuberculosis to HIV/AIDS—and it is important to note the centrality of diphtheria to early formulations of the carrier problem.[63] As Hammonds has charted, early ideas about the virulence of disease, immunity and the asymptomatic carrier developed through work on diphtheria.[64] In Australia the first reference to the asymptomatic carrier was also initially attached to diphtheria specifically. Interestingly this occurred in 1872, prior to the isolation of the

[61] Ashworth and Turner, op. cit., note 37 above; A J Turner, 'A few notes on the bacteriological diagnosis of diphtheria, and on the disappearance of the bacilli during convalescence', *Aust. med. J.*, 1896, **1**: 625–35; R R Stawell, 'Notes on the diagnosis and treatment of diphtheria', *Aust. med. J.*, 1896, **1**: 513–22; T Borthwick and H Irwin, 'Further notes on the antitoxin treatment of diphtheria', *Australas. med. Gaz.*, 1897, **16**: 25–9.

[62] Turner, op. cit., note 61 above, p. 628.

[63] See Raymond Donovan, 'The plaguing of a faggot, the leperising of a whore: criminally cultured AIDS bodies & carrier laws', *J. Aust. Stud.*, 1995, **43**: 110–24.

[64] Hardy, op. cit., note 1 above, p. 92; Hammonds, op. cit., note 1 above, pp. 157–67.

bacillus,[65] but, unlike New York, it was not until 1916 that the tracking of carriers, identified by throat swabs, became a large-scale preventive policy. Throat swabbing to reveal which contacts of the patient had become carriers, initially deployed in hospitals in Australia, became standard practice in response to any outbreak of the illness.

Until 1916, communities controlled diphtheria outbreaks by a system of disinfection and contact control. Such measures extended and integrated the traditional activities of local civic authorities, the local doctor and the local hospital. This local focus necessarily limited the scope of action and made diphtheria control responsive to epidemic outbreaks, rather than properly preventive of them. The mentality of local public health, and the absence of government resources outside the metropolis, made an active physician or hospital the linchpin of diphtheria control. "[The physician] can do a great deal towards preventing the spread of the disease from one member of the household to another and do it by leisurely, easy and rule of thumb methods", as Dr Frederick Scholes urged his fellow physicians. Treating the patient with antitoxin, swabbing the throats of the patient's family to detect carriers, prescribing quarantines within quarantines (the patient within the house, the house, the movements of contacts), disinfecting the patient's house, and notifying the incident were the standard and often onerous methods of containment employed.[66]

Though the use of antitoxin greatly lowered the case mortality, diphtheria hardly diminished in importance in communities where outbreaks, and the techniques used to manage them, continued to disrupt daily life. Diphtheria was associated with two community institutions which were cultural symbols of "health" and health management: the milk supply and the school. These sites were singled out for surveillance in outbreaks of diphtheria as both facilitated the easy transmission of droplet infections. Milk symbolized "health" in itself—the guarantee of a clean milk supply to urban districts was a preoccupying issue of the early twentieth century—but was simultaneously and paradoxically problematized as a prime medium of disease transmission. Diphtheria outbreaks were often traced to dairies.[67] Great anxieties were, of course, centred on school transmission. Schools where outbreaks occurred were frequently closed, often for up to a month at a time, while the buildings (especially watertanks) were disinfected and the epidemic subsided. In 1912, fifty-nine schools in the state of Victoria alone were closed for periods between a week and a month because of outbreaks of diphtheria.[68] These large and not infrequent disruptions to important community institutions maintained a consistently high level of public concern about the disease. Given the dramatic emergency treatments for the disease—intubation and tracheotomy, and this almost exclusively in young children—the significant cultural profile of diphtheria should not be surprising.

[65] Cumpston, op. cit., note 4 above, p. 297.

[66] F Allworth, 'Notes on a virulent diphtheria carrier', *Trans. Aust. med. Congress*, 1911, **1**: 502–3; F Scholes, 'The role of the practitioner in the control of diphtheria', *Med. J. Aust.*, 1924, **i**: 298–300.

[67] Cumpston, op. cit., note 19 above, pp. 42–4.

[68] G Halley, 'Diphtheria as a school problem', *Health*, 1923: 64–5.

Nevertheless, a shift in government attitude and structure was required to initiate large-scale preventive measures.

The register of diphtheria's importance in official public health policy was its incidence statistics. At the turn of the century, it was expected that the serious reduction in case mortality would be reflected in incidence and severity. Instead, despite overwhelmingly positive data from antitoxin serum use, diphtheria showed a larger and larger profile. The disease remained epidemic in nature, and its incidence increased steadily from 1906 onwards (though with some variations between different States, the reason for which was occasionally the subject of public health discussion), punctuated by various "peak" years of severe epidemic outbreaks.[69] Compiling his statistics in 1927, J H L Cumpston noted a "definite rise in the death rates" after 1908 in all States to between 10 and 20 per 100,000.[70]

In 1916, the release of the *Report of the Committee Concerning Causes of Death and Invalidity in the Commonwealth: Report on Diphtheria* made diphtheria control a high priority in public health policy. The inquiry was motivated by the exigencies of war with its newly emphatic realization that "national existence depended on human life and human health".[71] Importantly, it was during wartime that the Commonwealth government made bold moves with respect to preventive health, attempting to shift responsibility from reactive local communities to the systematic and large-scale swabbing and isolation campaigns, based on tracking carriers. Additionally the new Commonwealth government had a constitutional responsibility to pay invalid pensions. The economic imperatives driving new kinds of properly preventive public health measures should not be underestimated. For pragmatic and ideological reasons, broad-based preventive medicine instigated by a strong, centralized, Commonwealth government was now placed firmly on the political agenda.

The *Report* noted uneasily that the introduction of antitoxin treatment had had, in fact, only a minor affect on the death-rate for diphtheria, which was already falling before the treatment was available—and which, moreover, was beginning to rise once more.[72] That is, although antitoxin treatment reduced the *case* mortality, the overall death *rate* was unaffected. The *Report* raised the spectre of the uncontrollable and unknown nature of epidemic disease, which could strike with unguessed-at virulence at any time: diphtheria seemed to operate in cycles on an

[69] Cumpston, op. cit., note 19 above; J H L Cumpston, Report of his comments at the Section of Preventative Medicine and Tropical Hygiene meeting, *Med. J. Aust.*, 1929, **ii**: 43–5.

[70] Cumpston, op. cit., note 4 above, p. 294.

[71] Ibid., p. 423.

[72] *Report of the Committee Concerning Causes of Death and Invalidity in the Commonwealth: Report on Diphtheria,* Canberra, Government Printer, 1916 (hereafter *Report*). The Committee's terms of reference were to examine the principal causes of death and invalidity in Australia, and to report on suitable measures for their investigation and prevention. The Committee nominated five areas: diphtheria, typhoid fever, 'the risks of middle age', tuberculosis, venereal diseases, infantile mortality and maternal mortality. It was chaired by an MP, James Matthews, and consisted of three MDs, H B Allen, Dean of the Medical School, University of Melbourne, J H L Cumpston, Federal Director of Quarantine, and A Jeffreys Wood.

entirely powerless population.[73] It stated that more emphasis was required on preventative measures and shifted the entire weight of public health policy to laboratory managed scientific surveillance and to the concept of uncompromising "prevention".[74] In this report the problem of diphtheria control was almost exclusively conceptualized in terms of the "carrier problem"—a phrase which dominated the literature on diphtheria for the ensuing decade. Prevention was to be wholly accomplished by identifying, containing, and monitoring those who were the nodes of disease—apparently healthy people who carried the bacillus in their throats. The *Report* observed that existing Health Acts required the notification of cases only, and argued that the law ought to be extended to include carriers also. The proper control of diphtheria, in the view of the *Report*, would require the mobilization of the governmental apparatus for public health on an unprecedented scale. It envisaged the bacteriological examination of all cases of sore throat, the swabbing of all contacts of cases, the isolation of carriers, and the prevention of discharge from hospitals of any cases whose throat swabs still revealed bacilli. To accomplish this, the *Report* recommended equipping mobile laboratories to service rural communities.

The concerns of the *Report* were taken up favourably by the medical community. At a new series of meetings about diphtheria, physicians and medical scientists discussed how to identify the elusive carriers (frequently pictured as a sickly child, or one with enlarged tonsils) and their prevalence in the community. Some pointed out that while antitoxin treatment saved lives, it might have added to the "carrier" problem by preventing the deaths of weak children who now harboured it, too weak to entirely throw off the disease.[75] Physicians argued that a concerted campaign for the discovery and isolation of carriers would effectively control diphtheria. The prophylaxis of diphtheria, through a system of tracking, isolation and behavioural monitoring of carriers, would place diphtheria management clearly under a central governmental eye.[76] It was largely the concern with diphtheria control that wrote the carrier problem into the law. Between 1919 and 1921, most Australian States passed legislation which enabled government agents and medical officers to treat all known "carriers" as if they were actually ill, and therefore legally subject to quarantine or enforced hospitalization.[77]

[73] Hammond describes in detail the inconclusive bacteriological and epidemiological research into diphtheria during the early twentieth century and the implications this had for carrier control and other preventive public health policies. While Australian physicians were also aware of the problems arising from the unknown factors affecting the virulence and infectivity of bacteriology, especially as the concept of monomorphism was gradually relinquished, public health officials were more concerned with practical measures for prevention in the face of these unmeasurable variables. See Hammond, op. cit., note 1 above, pp. 138–65.

[74] Ibid., pp. 1–6; 14–15.

[75] Ibid., p. 6; Scholes, op. cit., note 31 above; Scholes, op. cit., note 66 above.

[76] 'The prevention of diphtheria', *Med. J. Aust.*, 1921, **ii**: 291.

[77] The amendments to the Health Act in Western Australia provided for this as early as 1911; see also Health Act, 1919, Victoria, and Health Act, 1921, New South Wales, which were referred to in medical journals. Similar legislation existed in the other States. See Cumpston, op. cit., note 4 above, p. 397.

Response to the carrier problem was considered in terms of large mobilizations of government resources and power. The editor of the *Medical Journal of Australia* wrote in 1918:

> It must be borne in mind that if the throats of all persons could be examined by the usual method known as swabbing, and if all persons harbouring the bacilli were isolated until the bacilli disappeared, the disease would necessarily die out. It, therefore, becomes a question of expense. In the present circumstances, it would be Utopian to expect the State Governments to sanction the expenditure necessary to control the fauces of the whole community. Much, however, can be accomplished by a methodical search for carriers in the environment of every notified case.[78]

This utopian examination and control of each individual member of a compliant population was unrealizable on the grounds of both finance and of public consent. None the less, official policy drove extremely large anti-diphtheria campaigns, which were conducted according to such recommendations over the next five years. When an outbreak occurred, wholesale swabbing of all conceivable contacts frequently took place with the subsequent isolation of any carriers discovered. As patients and contacts were overwhelmingly likely to be children, this often resulted in the swabbing of entire schools and communities. The scale of these campaigns, particularly in rural areas, was hitherto unheard of in Australia. In one typical report, Dr Legge of Swan Hill, Victoria, reported that 134 swabs were taken in school, and altogether 290 contacts swabbed; the State and Sunday schools were closed for three weeks, and before any patient was allowed back to school he or she was reswabbed. In Tallangatta, 530 swabs were taken of the whole population, resulting in the discovery and isolation of 10 carriers. In Bendigo, over 7,000 swabs resulted in the isolation of more than 500 carriers.[79] These and other reports were published as exemplars of successful campaigns when the immediate statistics showed a drop of over 50 per cent in the incidence rate.

Response to the carrier problem in its institutional and cultural manifestations both shaped, and was shaped by, early-twentieth-century discourse on childhood. Children were regarded as particularly dangerous carriers. Socially, this derived from the difficulty of governing children's behaviour, since most juvenile carriers could not be expected to control all aspects of their behaviour that might lead to infection. Medically, child "carriers" were pathologized as chronically unwell children, usually former sufferers, deprived of the ability to create their own "natural" immune defences to the bacilli by the use of antitoxin (which produced a short-term "artificial immunity").[80] Diphtheria control became one important aspect of the attempt to monitor all childhood behaviour, and of the growing medicalization of childhood and schooling at this time. School-based public health instrumentalities, a range of strategies of control and measurement, proliferated from the turn of the century. These included regular examinations for an increasing range of diseases, checks for

[78] 'The prevention of diphtheria', *Med. J. Aust.*, 1918, **i**: pp. 90–1.

[79] F R Legge, 'Prevention of diphtheria', *Med. J. Aust.*, 1918, **i**: 391; 'Prevention of diphtheria', *Med. J. Aust.*, 1921, **ii**: 417.

[80] Scholes, op. cit., note 66 above, p. 299.

parasites such as lice, hygiene practices, and the construction of physical and mental norms from age–height ratios to the Binet IQ test. In the lengthy list of childhood medical abnormalities to be covered by medical inspection, enlarged tonsils were specified as a serious physical defect in children, indicating "carrier" status and associated with illness and delinquency.[81] In many such cases surgery was pursued as a prophylactic tool.[82] Children who swabbed positively for diphtheria for a month or more were typically subjected to tonsillectomy, a strategy sometimes resorted to wholesale in children's institutions such as orphanages.[83]

In the brief period between 1916 and 1922 in which the disease and its prophylaxis were entirely identified with the carrier problem, diphtheria proved to be more difficult to control than initially hoped. Despite some successes, a variety of problems made it clear that these cumbersome campaigns were not, and perhaps could not be, effective. The potentially draconian interventions by the state were contested in several public and medical sites. Firstly, there was enough variation in bacteriological testing to cast doubt on the validity of swabbing campaigns. The medical literature carried an increasing number of reports of cases where swabs returned false negatives,[84] and other physicians argued that "not all carriers were equally dangerous" and in need of isolation.[85] In the frequent cases where the onerous task of isolating a child or keeping an entirely healthy breadwinner in quarantine was protracted beyond a week, physician and family alike complained of the harshness of the procedure. Moreover, as was periodically noted, the isolation of children at home, especially in small houses, was often more a farcical than an effective strategy.

Immunization against Diphtheria, 1922–1928

We have argued that the application of bacteriological techniques in the prevention of diphtheria varied over time and was dependent on context, rather than being a predictable or consistent outcome simply of the availability of certain knowledge or procedures. This was dramatically evident in the early 1920s when there was another shift, this time from the swabbing and isolation campaigns towards a policy of mass immunization. By the early 1920s, diphtheria control was already a centrepiece of Australian preventive public health policy. It was to become even more important as the disease against which modern immunization practices were founded.

In 1921, the *Medical Journal of Australia* considered, with respect to the swabbing and isolation campaigns that

> [t]o rid the six Australian states of diphtheria would necessitate an elaborate and well organized campaign. It would cost a large sum of money, but not so large a sum as diphtheria itself

[81] Jan Kociumbas, *Australian childhood: a history*, St Leonards, NSW, Allen and Unwin, 1997, pp. 159–60.

[82] F V Scholes, 'The release of diphtheria convalescents', *Health*, 1923: 61–3.

[83] Kociumbas, op. cit., note 81 above, pp. 159–60.

[84] See Legge, op. cit., note 79 above. Complaints were still being made in 1929. See A H Powell, 'Diphtheria', *Med. J. Aust.*, 1929, **ii**: 69.

[85] Scholes, op. cit., note 82 above, p. 62; 'The prevention of diphtheria', *Med. J. Aust.*, 1921, **ii**: 290–2. See also Hammonds' discussion of these problems in New York as physicians grappled with differences and immunity to the disease and to variations in virulence. Hammonds, op. cit., note 1 above.

costs the community. It might involve co-ordinated work, spread over several years. But it would be worth while doing.[86]

Exactly a year later, enthusiasm for swabbing and isolation had suddenly turned into great disillusionment:

> Each year there is an unnecessary wastage of valuable lives and a regrettable loss of energy and money in the Commonwealth resulting from diphtheria. The annual statistics reveal a deplorable state of affairs, a definite defect of the machinery for the protection of the public health . . . The aetiology and pathology of the disease is [*sic*] well understood; much information concerning its epidemiology has been collected; the possibility of its prevention has been demonstrated. It may be of use . . . to urge those who are responsible for the preservation of the public health, to introduce new methods for the prevention of this dangerous disease.[87]

The editor argued for the introduction of mass immunization against the disease. The case of diphtheria illuminates how vaccination, perceived as a strange and risky procedure in the nineteenth century, was normalized in the twentieth. Although smallpox vaccination provided early individual, governmental and medical experience of vaccination, it was not smallpox but diphtheria which was central to the development of modern practices and expectations of mass immunization. Levels of smallpox vaccination had declined so significantly since the end of the nineteenth century that it was estimated that 98 per cent of the population was unprotected in 1920.[88] Despite fairly regular and highly publicized smallpox outbreaks in several States since the turn of the century (Tasmania in 1903; New South Wales, 1913; Western Australia, 1914; South Australia 1915; Victoria, 1921) there was little community sense of urgency about, or compliance with, vaccination campaigns. None the less, vaccination was far from a forgotten idea, clinically or popularly. In addition to smallpox vaccines, it had been known from the time of serum therapy usage that doses of antitoxin serum provided short-term passive immunity against diphtheria in nurses and carers. Considerable international research and development into prophylactic vaccines could be drawn on in Australia. During the war, for example, the Australian army had made successful use of anti-typhoid vaccines in overseas service. And vaccines for other diseases, such as pertussis (whooping cough), were available through occasional enterprising practitioners at private request.[89]

Notwithstanding the availability of other kinds of vaccines, it was specifically diphtheria which became fully identified with immunization from the 1920s in Australia. Toxin-antitoxin (TAT) vaccines which produced long-lasting active immunization had been successfully trialled in New York and Germany before the First World War. Concern about the use of unmodified toxin led to the development of other forms of vaccine, such as anatoxin, which was a serum treated with formalin, and alum precipitated toxoid. Although these procedures were developed and

[86] 'The prevention of diphtheria', ibid., p. 291.

[87] 'The prevention of diphtheria', *Med. J. Aust.*, 1922, **ii**: 418.

[88] H B Allen, 'A discussion of vaccines and serum therapy', *Trans. Aust. med. Congress*, 1911, **1**: 135–45.

[89] Brian Feery, 'Impact of immunization on disease in Australia', *Med. J. Aust.*, 1981, **135**: 172–6.

available overseas well before the 1920s, so entrenched was the swabbing-carrier-isolation regime of prevention in Australia, that no serious attempt to incorporate the new vaccines into clinical and preventive practice was made until 1922. The commitment to swabbing and isolation had entirely monopolized medical and government energies and directions.

It became clear that the swabbing campaigns were unwieldy, and that the category of "carrier" created impossibly large isolation requirements. Indeed the strategy of identifying, tracing and isolating carriers created logistical problems greater than any capacity of government, especially local government, to respond. Yet the significance of the disease was ongoing, and the evidence of well documented successful campaigns in New York, Germany and Canada, as well the easy availability of immunizing material, made diphtheria the perfect candidate for a trial policy of mass vaccination. Most interest appears to have arisen in the state of Victoria, where the initiative taken by local authorities in large urban wards trialled the policy in dense, accessible populations. The process of instituting mass childhood vaccination elsewhere in Australia was piecemeal.

The negotiation between local and central styles of public health, and the availability of resources (from vaccine material manufactured by the Commonwealth Serum Laboratories,[90] to trained administrators) crucially determined the progress of policy implementation, as Jane Lewis describes for Canada and Britain.[91] Although public health officials at State and Commonwealth government levels advocated immunization schemes, in the 1920s their implementation depended on the decision of each local Council and the co-operation of each local Medical Officer of Health (usually one of the general practitioners in the area). In 1923 the city of Bendigo in Victoria carried out the first major campaign, followed the next year by the city of Melbourne, and then by a trickle of shire and borough councils around Australia. New South Wales officials rather apologetically attributed their laxness to the demands caused by the outbreak of plague. The majority of Councils did not follow suit until the Second World War. In general, immunization was to be limited to children in some kind of institution—orphanages, and of course schools—where diphtheria was prevalent. The large-scale swabbing, isolation and cleansing which had formerly been deployed against diphtheria had been organized specifically through schools, and this offered the organizational structure for the implementation of the immunization campaign.

Immunization in schools was carried out only with the written consent of parents or guardians: it was not compulsory. In reports from the Victorian Commission of Public Health to the Minister for Health, community resistance to compulsory immunization was referred to, recommending that "efforts to make compulsory inoculations against diphtheria would be quite futile".[92] Moreover to minimize costs and prevent excessive intervention, vaccination was given only to susceptible children. Susceptibility tests for diphtheria and scarlet fever had been developed and used to

[90] Claire Hooker, 'Diphtheria, immunisation and the Bundaberg tragedy: a study in public health in Australia', *Health and History*, 2000, **2**: 52–78.

[91] Lewis, op. cit., note 1 above.

[92] 'The Schick Test and toxin antitoxin immunisation', *Health Bull.*, 1925, **3**: 12–13.

monitor infection and carrier contacts, as public health officials attempted to map the progress of epidemic disease through the population. The Schick test, in which a minute quantity of diphtheria toxin was injected subcutaneously to see if the body would react to it, was widely adopted as a precursor to immunization: only children with positive tests were immunized.[93] The campaigns were on an even larger scale than the previous swabbing campaigns had been: in 1924, one of the earliest such campaigns, that of Melbourne city under the direction of Dr Annie Hensley, Schick tested 11,230 school children.[94]

The normalization of immunization that eventually occurred over the course of the twentieth century, was initially qualified by two major factors: first, ongoing anti-vaccinationist arguments which had developed around smallpox immediately transferred to the question of diphtheria; second, the logistics of local implementation proved difficult. Vaccination was regarded culturally as a problematic procedure, associated with coercive policies during the previous century. To implement it was a politically risky decision and any advocate would be faced with a vocal opposition.[95] Yet there was a more subtle caution about vaccination at work, even amongst policy makers, which concerned the very different logic of prevention it implied.[96] Tracing "carriers", prescribing habits of life and isolations, notification and cleansing by local physicians or Medical Officers of Health were all instrumentalities embedded in the longstanding traditions of sanitary and hygienic approaches to public health, those concerned with "cleanliness".[97] Vaccination represented a clear break with these techniques, even though it was a procedure which had been practised for more than a century. The published medical debate certainly indicates that mass immunization was perceived as a rupture in preventive approaches: "It is useless to require a sanitary inspector to look at the drains of a house from which a notification is sent. The prophylaxis of diphtheria is not a sanitary matter and the sanitary inspector is not needed for this task".[98] A series of critiques levelled at the technology of notification at this time similarly indicated a contemporary perception that a profound change in attitude accompanied the move towards immunization.[99] There

[93] Scholes, op. cit., note 31 above.

[94] Cumpston, op. cit., note 19 above. See also Hooker, op. cit., note 90 above.

[95] As in Britain, the question of vaccination and compulsory vaccination was debated constantly by Australian governments. See 'Report from the Select Committee upon Vaccination Law', Victoria Legislative Assembly, *Votes and Proceedings*, 1880–82, vol. 2, pp. i–v, 1–39; 'Select Committee upon the Efficacy of Vaccination', Victoria Legislative Assembly, *Votes and Proceedings*, 1915, pp. i–xv; 'Compulsory vaccination: medical opinions', NSW Legislative Assembly, *Votes and Proceedings*, 1881, vol. 4, pp. 1019–73; *Petition against compulsory vaccination*, Adelaide, Government Printer, 1900.

[96] Vaccination against smallpox worked through a logic of "contagion" (the introduction of a foreign body into an individual and its exponential spread through the social body) rather than a logic of quarantine (the clear separation of clean and dirty). See Alison Bashford, 'Foreign bodies: vaccination, contagion and colonialism in the nineteenth century', in Alison Bashford and Claire Hooker (eds), *Contagion: historical and cultural studies*, London, Routledge, 2001, pp. 39–60.

[97] For further discussion of the use of the term "sanitary" and its implications in public health practice see Claire Hooker, 'Sanitary failure and risk: Pasteurisation, immunisation and the logics of prevention', in Bashford and Hooker (eds), op. cit., note 96 above.

[98] 'The prevention of diphtheria', *Med. J. Aust.*, 1921, **ii**: 291.

[99] Scholes, op. cit., note 31 above; Frank Hone, 'Notification or prevention: which?', *Report of the eighteenth meeting of the Australasian Association for the Advancement of Science*, 1928, **18**: 675–93.

was considerable hesitation over abandoning a public health framework whose benefits potentially lasted beyond the immediate demands of epidemic control and affected education and well-being more generally.[100] This is partly why no suggestion was made of using immunization against any other diseases, apart from smallpox. Effective vaccines were available for typhoid and other enteric diseases, but sanitary measures continued to be regarded by many public health experts as not only the most effective, but the most desirable, forms of control for them.[101]

In addition to the investments in sanitary models of disease control, vaccination itself was treated with some caution. As Lewis has argued of the British context (and despite extensive research and production of vaccine material there), physicians were unsure of its value, doubting, for example, whether it would be effective on persistent carriers on whom antitoxin serum had not worked.[102] They even feared an increase in numbers of carriers. A mistrustful attitude was understandable given that contemporary vaccine trials against scarlet fever, tuberculosis and other illnesses were yielding mixed, sometimes disastrous, results.[103] Even Cumpston, Commonwealth Director-General of Health and prime activist for large-scale public health schemes, referred to immunization as experimental and inconclusive, though indicating success so far as diphtheria was concerned.[104]

The existing machinery for public health implementation also contributed to the diffident fashion in which mass immunization was introduced. Certainly some of the early local immunization campaigns were large-scale and successful in their own terms, particularly in Victoria. However, the local nature and the very informality of its introduction nearly became the downfall of the policy, since its success, in epidemiological terms, relied on macro changes in population immunity which were difficult to achieve. The immediate results of the early Australian campaigns were not as positive as those touted by advocates in the medical literature from New York and Toronto. Epidemiological statistics and reports of campaigns generally showed a less dramatic decrease in diphtheria incidence than initially expected.[105] Such reports did indicate that incidence was almost wholly confined to the unimmunized population. Studies in institutional settings (where the issue of consent could be waived) showed that the "herd immunity" needed to reach levels of 70 per cent or above if incidence rates were to be seriously affected.[106] Even with a fully co-operative community response, these levels would be difficult to obtain.[107]

The actual practice and implementation of immunization against diphtheria in Australia, as opposed to bureaucratic support for a policy of immunization, was ad

[100] Sinclair, op. cit., note 56 above.

[101] See J Dale, 'The prevention and control of diphtheria and scarlet fever', *Trans. Aust. med. Congress*, 1929: 32–41.

[102] Lewis, op. cit., note 1, p. 167.

[103] 'Diphtheria and scarlet fever', *Med. J. Aust.*, 1929, ii: 525–7.

[104] Cumpston, op. cit., note 69 above, pp. 43–5.

[105] Cumpston, op. cit., note 19 above, p. 52; J Dale, 'Immunization against diphtheria: a report on the work done in the municipality of Melbourne', *Health Bull.*, 1929, **17**: 577–80; Hallam, 'Diphtheria prophylaxis' and 'Diphtheria in Victoria', op. cit., note 16 above.

[106] Sheldon Dudley, 'The possibility of forecasting outbreaks of diphtheria', *Trans. Australas. med. Congress*, 1927: 455–61.

[107] For further detail, see Hooker, op. cit., note 90 above.

hoc, local and slow to proceed. None the less, the Australian public grew more accepting of immunization as the procedure was more efficiently encouraged and implemented. This was despite the 1928 "Bundaberg disaster" in which 12 children died within twenty-four hours as a result of diphtheria immunization.[108] One outcome of the tragedy was a more experimental approach, and the adoption of alternative forms of immunization material. However, it was again the emotional and governmental context of wartime that provided a fertile context for immunization to be applied on a population-wide level. In 1953 the "triple antigen" combining diphtheria, tetanus and whooping cough in a single injection was introduced in Australia, and became routine practice in the medical management of infants and young children.

Conclusion

Diphtheria was one of the earliest diseases to be considered in terms of an infectious microbe as necessary and sufficient cause. Once the organism was isolated, there was never quite that debate and disagreement over its fundamental aetiology which characterized understanding of other infectious diseases over this period. Rather, as Anne Hardy and Evelynn Hammonds have noted of the British and American contexts respectively, and as we have found in the Australian, there was notable agreement which resulted in diphtheria's status as a kind of quintessential way of arguing for bacteriological approaches to infectious disease control. Classically defined by the framework of the "bacteriological revolution", yet recalcitrant to control within it, diphtheria offers ways of understanding how complex the implications of bacteriology were for preventive medicine and public health. Those who worked within the new bacteriological paradigm often expected, or at least hoped for, a clarification of procedures for diagnosis and prevention of infectious diseases, procedures which had previously been uncertain, unfounded and often ineffective. Certainly subsequent commentators have argued fairly simplistically that this certainty *was* offered, indeed necessitated, by the new laboratory-based public health. We have sought to complicate the history of applied bacteriology in its interface with government and public health, by offering a specific and local study.

By this, we mean not only the necessity to examine the local social and cultural conditions of a public health system, but that the specific characteristics of particular diseases are important. Diphtheria was so closely identified with bacteriology and subsequently with applied public health in Australia, because of the actions of the bacillus and its possible observation in the laboratory. That it was a disease of children was especially significant because that particular sector of the population was already contained and managed in certain ways through an education system: this was a group considered accessible, and whose conduct was already subject to all kinds of interventions by government. This already-existing structure for the management of children invited the large-scale interventions of both the swabbing

[108] Virtually all diphtheria immunization was suspended in Australia for two years after this tragedy. See Minutes of evidence of *Royal Commission of Inquiry into Fatalities at Bundaberg*, Government Printer, Canberra, 1928. For further details, see ibid.

and the immunization campaigns. The health management of people with TB or syphilis or typhoid, for example, developed quite differently precisely because the "problem" population was not as easily definable, accessible or manageable. Diphtheria's status as a disease of children also determined its historical significance for immunization practices in Australia: although vaccines existed for other diseases, because they were not childhood diseases there was no immediately available infrastructure for the implementation of large-scale campaigns. Diphtheria was central to the development of Australian public health policy and instrumentalities: its government-funded laboratories; the conception, and then abandonment of, notification as a primary controlling technology; the regulation of vaccine matter and methods of implementation; the integration of school systems with health systems; and the conceptualization of large-scale control and eradication programmes on a long-term basis.

We have identified a number of different policies for the prevention of this single important disease in the Australian context; policies which changed remarkably quickly. While we have by no means presented exhaustively the reasons for these changes, we have documented the complexities within the history of applied public health in this crucial period after the general acceptance of "germ theory", after the "laboratory revolution in medicine". Dramatic shifts in policies and practices concerning diphtheria demonstrate the range of approaches consequent to the identification of a microbe as necessary and sufficient cause for a particular disease: notification based on newly certain diagnosis; isolation in hospitals; tracking and managing the carrier through mass swabbing; and immunization. None of the preventive approaches was an obvious or necessary response, but each was taken up and abandoned for particular, if complicated reasons, which demand close historical attention. Bacteriology certainly "solved" prior problems of differential diagnosis with respect to diphtheria, but we have been keen to illustrate the ways in which bacteriological knowledge and techniques also produced new problems and new confusions in diagnosis, in classification and in the creation of new categories of illness such as the "carrier". Indeed, a study of diphtheria requires recognition that a disease which was early defined by—and thus helped to define—this "laboratory revolution" as the basis for modern public health, could also consistently challenge notions of infection and disease control at every stage of public health development.