Totem: The University of Western Ontario Journal of Anthropology

Volume 8 | Issue 1 Article 2

6-21-2011

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Tracey Galloway
The University of Western Ontario

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Keywords
epidemiologic transition, epidemiology, M.R.S.A.

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Tracey Galloway

In 1971, Abdel R. Omran proposed *The Epidemiologic Transition*, a theory of changing demography and health patterns in populations over time. Omran's theoretical model contained four propositions:

(1) The theory of epidemiologic transition begins with the major premise that mortality is a fundamental factor in population dynamics.
(2) During the transition, a long-term shift occurs in mortality and disease patterns whereby pandemics of infection are gradually displaced by degenerative and man-made diseases as the chief form of morbidity and primary cause of death.
(3) During the epidemiologic transition the most profound changes in health and disease patterns obtain among children and young women.
(4) The shifts in health and disease patterns that characterize the epidemiologic transition are closely associated with the demographic and socioeconomic transition that constitute the modernization complex.

(Omran 1971:511-527)

In 1977, Omran published *Epidemiologic Transition in the U.S.*, which not only applied his model to American health patterns since the 18th century, but refined proposition (4) to describe three types of model (Classic or Western, Accelerated, and Delayed) based on the timing and peculiar dynamics of change in a nation.

Although it originated in a climate of economic growth and Western-mediated development, Omran's theory has proven useful for application beyond Western boundaries. In general, as countries enter the global economy and industrialize, high infectious disease mortality gives way to longer life expectancies and new leading causes of death, such as degenerative and cardiovascular diseases. (Wolleswinkel-Van Den Bosch *et al.* 1997; Tulchinsky *et al.* 1996; and Hofer Levison *et al.* 1981)

An interesting paper by Rogers and Hackenberg (1987) suggests that developed societies have moved beyond the stages proposed by Omran, and entered a new stage of epidemiologic transition: the Hybristic (*sic*) stage. Characterized by a majority of morbidity and mortality associated with lifestyle and behaviour-mediated disease processes, the Hybristic stage arises out of the "excessive self-confidence" or *hubris* that Rogers and Hackenberg believe pervades Western society.

As a recognition that some societies have progressed beyond the boundaries of Omran's proposals, the hybristic hypothesis has merit. As an examination of Western demography and health processes, Rogers and Hackenberg's thesis focuses narrowly on the intrinsic (or individual) factors involved in mediating human health patterns. Certainly lifestyle choices, personal

hygiene practices, dietary preferences and antibiotic use are intrinsic factors that contribute greatly to morbidity and mortality. But responsible discussions of social epidemiology must include both intrinsic and extrinsic factors, linking the actions of individuals to the conditions of the larger social, political and environmental systems they inhabit (Singer *et al.* 1998). Public policy limits the health care access of marginalized groups, and powerful pharmaceutical, technological and medical lobbies ensure the high priority of tertiary hospital care. Though governments in the industrial West are shifting from a hospital focus to higher public health expenditures, political expediencies slow this shift and maintain the expensive, high profile programs that generate revenue and media attention. Legislation to slow the pace of environmental degradation is also subject to political expediencies and powerful industrial lobbies.

I believe that *inherent in the process of the epidemiologic transition is the creation of conditions which necessitate its reverse*. The testing of this hypothesis would be a lifetime's work, and I presume no such ambition. However, an examination of the literature on one disease event may suffice to explore this idea. I hypothesize that the emergence of Methicillin-resistant *Staphylococcus aureus* (M.R.S.A.) is a response to both intrinsic and extrinsic factors embedded in the later stages of the epidemiologic transition. This paper will examine M.R.S.A. as a disease event that reflects the individual, societal, political and environmental climate of industrialized nations in the late 20th century. Just one of an alarming number of formerly treatable pathogens that have acquired resistant properties, M.R.S.A. challenges Omran's notion of eventual freedom from majority mortality and morbidity caused by pandemic infectious disease. I will discuss the emergence of M.R.S.A. as inexorably linked to the very factors which permitted Western nations to reach Omran's "Age of Degenerative and Man-Made Disease" (1971). With a description of several recent M.R.S.A. outbreaks in Europe, Australia and North America, I will discuss the potential of this disease to fundamentally alter our linear conception of the epidemiologic transition.

Omran (1971) proposed several models of epidemiologic transition, differentiated by the rate and quality of demographic change experienced by a society. This discussion will examine recent literature from Europe, North America and Australia. Although Omran based his "Classical (Western) Model of Epidemiologic Transition" on European populations, many factors justify the inclusion of North America and Australia in an examination of the Classical Model. Long periods of European colonial occupation have resulted in majority populations of European descent. Similar democratic and capitalist structures dominate these geographical regions, and the industrialization and urbanization of North America and Australia have largely mirrored that of Europe. For these reasons, I will address these three regions under the Classical (Western) Model.

In the final phase of the epidemiologic transition, Omran (1971) divides his analysis into four profiles: population, economic, society and health. I will address each of these in turn, and discuss the individual, social, political and environmental implications of each profile.

POPULATION

As Western nations reached the Age of Degenerative and Man-Made Disease, population statistics were characterized by decreasing mortality rates, decreasing fertility rates, and a progressive aging of the population (Omran 1971). Although medical technology is an important factor in these changes, far more influential are the progressive advances in nutrition, sanitation, education and standard of living achieved by these industrialized nations (Mann *et al.* 1996). Although differential access remains a concern to marginalized groups, the majority of the population has access to the education and infrastructure which support health improvement. As life expectancy increases and infant mortality decreases, populations support a larger dependency burden. In the West, the response to the dependency burden has been the institutionalization of care of the very young and especially, the very old. Day care centres and pre-kindergarten programs house pre-schoolers, and institutionalized education systems result in aggregations of school-age children. Retirement communities, nursing homes, seniors' apartments, recreation centres and respite care facilities all support large concentrations of the elderly. These institutions serve valuable purposes in the education and support of children and seniors, providing much of the knowledge and comfort that constitutes a high standard of living. At the same time, these structures provide the concentration of population necessary for the spread of infectious disease.

ECONOMICS

Europe, North America and Australia are all regions characterized by the capitalist mode of exchange (Todaro 1997). Wage labour takes place largely outside the household, in the institutionalized settings of manufacture, service and retail. These workplaces provide the social conditions necessary for the spread of infectious disease. Concentrations of industry, service and retail, have resulted in the large urban centres that characterize Western population distribution. Commodification of labour and resources limits the financial success of groups with little access to capital, such as the poor, the disabled, and indigenous populations (Todaro 1997). Despite and in some cases because of government assistance programs, these groups are largely institutionalized, living and working in environments conducive to the spread of infectious disease.

A major effect of industrial expansion is concomitant environmental degradation. Though regulated by government legislation, industry and its products are responsible for damage to life-sustaining resources. Air pollution plagues major urban centres, and is directly related to industrial emissions and automobile use (Todaro 1997). Water treatment and waste disposal are grave concerns for industry as well as large urban centres.

Thus, in many ways the economic conditions of the Age of Degenerative and Man-Made Disease are fundamental to the eradication of epidemic infectious disease. But in the urbanization of population, in the institutionalization of work, in the marginalization of the underprivileged and in the degradation of the environment, lie the seeds of re-emergence of infectious disease as a majority cause of morbidity and mortality.

SOCIETY

Omran (1971) suggests that the social changes of this stage include the adoption of small family size, the emancipation of women from traditional roles, and a progressive rise in living conditions. With lower infant mortality and women involved in wage labour outside the home, family size generally decreases, and institutions develop to serve the child-care needs of families (Omran 1977). Certainly improved education (especially for women) is a cornerstone of improved health and lower infectious disease rates.

Many changes in community structure are brought about by industrialization, as families locate their households close to the workplaces and institutions that support them. Residence distant from one's community of birth results in the spread of extended families and neighborhoods over large geographical areas. Transportation and communication technologies permit contact between these extended communities. But, as we will discover in our examination of M.R.S.A., travel plays a large role in the spread of infectious disease. The mobility of Western populations is one of the most serious challenges to the control of potential epidemics.

HEALTH

All nations who have undergone Classical-Model epidemiologic transition exhibit institutionalized health care. Urban centres support large tertiary care hospitals, with aggregations of specialized care facilities. Biomedicine is a multi-billion dollar industry, composed of powerful transnational companies, professional organizations, lobby groups and service industries. Despite a recognition of the supremacy of public health endeavors in improving quality of life (Omran 1977), the majority of Western health care dollars are spent in the hospital sector (Gupta *et al.* 1998).

The discovery of antibiotics revolutionized 20th century medicine, and has contributed enormously to the eradication of epidemic infectious disease from the West (though less than the public health measures of education and improved sanitation). However, the late 20th century has seen the development of heavy reliance on antibiotic medication. Broad access to health care has developed into broad access to drugs, with frequent use of antibiotics for questionable treatment of unconfirmed viral and bacterial illness. Antibacterial agents are ineffective in treating viral illness, and their inappropriate prescription is often compounded by non-compliance with the recommended dosing schedule. Powerful pharmaceutical lobbies fuel this drug culture with advertisements and "public education", extolling the virtues of available medication (i.e. "Ask your doctor for..."). Bactericidal chemicals are added to a wide variety of products, such as dish soap, household cleaners and laundry products. Public attention has become focused on the need for a bacteria-free environment, rather than individual health and immunity. Perhaps tied to both education and the move away from household agriculture and food production, this culture of antibiotic use has reached a peak in both Europe and North America. There is increasing evidence in the media of public concern over antibiotic use in the food production industry. Perhaps a re-examination of human antibiotic consumption is not far behind.

Omran suggests that concern over health care spending characterizes the final stage of the epidemiologic

transition (1971). Increasingly, health care budgets fall victim to governmental deficit reduction programs. As the literature on M.R.S.A. will suggest, hospital-ward closures, staff cutbacks, and crowded emergency departments are significant factors in the spread of bacteria.

The final factor Omran addresses is decreasing vigilance in the area of infectious disease. Despite widespread eradication many infections (polio, measles), marginalized populations harbour significant levels of infectious agents, such as tuberculosis and HIV (Mann *et al.*, 1996). There are both moral and epidemiologic costs of ignoring this reservoir of infectious disease.

M.R.S.A.

In 1883, *Staphylococcus aureus* was isolated and identified as a nosocomial and community pathogen (Ogston 1883). Normal flora on the surface of skin in about 30% of people (Archer 1998), this bacterium is a common cause of superficial skin infections (i.e. cellulitis, folliculitis, carbuncles, furuncles, impetigo). Colonized individuals carry *S. aureus* bacteria both on the skin and in the mucous membranes of their nostrils and perineal areas. Deeper wound and soft tissue infections, as well as pneumonia and primary bloodstream infections (sepsis) are the predominant forms of nosocomial, or hospital-acquired, *S. aureus* infections. Community-acquired *S. aureus* ranges from colonization to superficial and invasive infections. In the pre-antibiotic era, the case fatality rate of *S. aureus* bloodstream infection was 82%. (Smith *et al.* 1999)

The prevalence of *S. aureus* colonization ensures that the bacterium is endemic in both community and institutional settings. The tendency toward antibiotic resistance in *S. aureus* is a combination of genetic and biochemical factors that flourish in dense aggregations of colonized and infected people. Benzylpenicillin was introduced in 1941 and used to treat *S. aureus* infections. By 1942, penicillin-resistant S. *aureus* was clinically documented (Rammelkamp *et al.* 1942). Currently, 80-90% of *S. aureus* isolates are resistant to penicillin, and the antimicrobial of choice for treatment of infection is methicillin. (Smith *et al.* 1999)

First used clinically in 1959, methicillin has enjoyed a long tenure as the drug of choice for *S. aureus* infection. The first strains of methicillin-resistant *S. aureus* (M.R.S.A.) were identified in 1961 (Jevons *et al.* 1963). The U.S. National Nosocomial Infections Surveillance system (N.N.I.S.) reports that the proportion of methicillin-resistant cases of all *S. aureus* infections rose from 2.4% in 1975 to 29% in 1991. In the larger N.N.I.S. hospitals of 500 beds or more, the proportion was 38.3% by 1991. (Banerjee *et al.* 1991)

Clearly, large tertiary care facilities in metropolitan centres are significant reservoirs of M.R.S.A. Investigators cite numerous instances where hospitalization is a significant predictor of M.R.S.A. infection (Beaujean *et al.* 1999; Kohner *et al.* 1999; Leski *et al.* 1999; Verhoef *et al.* 1999). An M.R.S.A. outbreak in a western Australian teaching hospital in Perth surprised many epidemiologists and microbiologists, whose confidence in their geographical isolation and state-wide screening policy had hitherto been rewarded by low incidence of resistant *S. aureus*. The source of the Australian infection was traced to a nursing home and a small county hospital, two institutions involved

in the care of the elderly and the sick. Though not large centres, these institutions provided the aggregations of colonized individuals and use of medication required for antibiotic-resistance. Movement of people from these centres to the Perth teaching hospital facilitated the spread of M.R.S.A. (O'Brien *et al.* 1999)

Leski *et al.* (1999) have examined the occurrence of M.R.S.A. in the neonatal and pediatric wards of hospitals in Warsaw, Poland. Improvements in obstetric, neonatal and pediatric care have significantly decreased the infant mortality rates of industrialized nations. But the centralized neonatal and pediatric wards which treat congenital and childhood diseases provide concentrations of children from various peri-urban areas. In environments where colonized individuals mingle with non-colonized individuals and antibiotics are used, M.R.S.A. is increasingly common. A similar study of a Czech hospital in Prague revealed a high incidence of M.R.S.A. in that hospital's burn unit. The highly specialized nature of burn therapy requires patients to be transported to central settings; the particular infection risks posed by burns place these patients at significant risk for M.R.S.A. infection. Both institutionalized health care and mobility of populations make this possible. (Melter *et al.* 1999)

Canadian investigators have documented an outbreak of *S. aureus* colonization in a Toronto day care centre. The index case for the outbreak was found to be a child with a history of repeat ear infections, hospitalization for bilateral tube placement, and subsequent outpatient and emergency room visits. Of 164 children screened, 40 were found to be colonized with *S. aureus,* including two with M.R.S.A. infections. There was a tendency for higher *S. aureus* carriage in children with personal histories of visits to hospital or emergency rooms or family histories of hospitalization, all within the previous 6 months. The institutional settings of hospitals and childcare centres foster the transmission of pathogens. (Shahin *et al.* 1999)

Studies of M.R.S.A. clonal types reveal the contribution mobility makes to the spread of M.R.S.A. Outbreaks in Spain, Portugal, Scotland, Italy, Belgium, Germany and New York have been linked to the same clonal strain of M.R.S.A. Melter *et al.* (1999:2798) examined isolates of M.R.S.A. from Czech hospitals and discovered both the Iberian (originating in Spain and Portugal) and Brazilian strains of M.R.S.A. They attribute this pattern to travel and the increase in tourism since 1990. Investigators in the Netherlands list travel and hospital stay as the most significant factors in the spread of M.R.S.A. (Beaujean *et al.* 1999; Melter *et al.* 1999;Verhoef *et al.* 1999).

Examination of the recent literature reveals a preponderance of biochemical responses to the increasing prevalence of M.R.S.A. At the Department of Veterans' Affairs Medical Centre in Brooklyn, New York, a change in the antibiotic formulary resulted in a decreased incidence of M.R.S.A. but a corresponding increase in antibiotic-resistant *Acinobacter* species (Landman *et al.* 1999). The authors suggest that while a change in antibiotics may control a single outbreak of a resistant pathogen, the consequences of providing a selective environment for another resistant pathogen are grave (Landman *et al.* 1999).

Despite such warnings, microbiologists continue to combat M.R.S.A. with biochemical therapy. The European SENTRY Antimicrobial

Surveillance Program warns that, because of the prevalence of increasing resistance, "...alternative antibiotics active against M.R.S.A. are urgently needed...the future for alternative M.R.S.A. treatment might lie with streptogramin and oxazolidinone compounds..." (Schmitz *et al.* 1999:529). The current topical agent of choice for surface infections and colonization reversal is mupirocin, an antibiotic that was introduced in the United Kingdom in 1985. Studies of mupirocin-resistant M.R.S.A. in U.K. hospitals have demonstrated increasing incidence, from 0.3% of *S. aureus* isolates in 1990 to 3.9% of *S. aureus* isolates in 1997 (Leski *et al.* 1990). A 1994 survey of U.K. medical centres documented the presence of mupirocin-resistant M.R.S.A. in 100 of 136 participating centres (Leski *et al.* 1990). Clearly, antibiotic resistance is an ongoing phenomenon.

By far the most promising news about M.R.S.A. comes from the Dutch literature. The incidence of methicillin-resistance is less than 1% of *S. aureus* isolates, compared to 30% in France, Italy and Spain, 50% in the United States, and 62.4% in Belgium. Epidemiologists in the Netherlands suggest that antibiotic use contributes less to the spread of M.R.S.A. than institutionalization and travel. In response to the threat of antibiotic-resistant disease, Dutch hospitals have implemented a triple-pronged approach to infection control, including isolation of new patients, widespread screening, and contact precautions. Isolation wards, private rooms for infected patients, community testing, adequate staffing and public education all contribute to the low incidence of M.R.S.A. in the Netherlands. Some hospitals are even considering workplace modifications, to restrict the access of colonized staff to non-colonized staff and patients. These measures cost money, and in the challenging political conditions of many Western nations, short-sighted bureaucratic decisions limit the education and infection control budgets of hospitals and public health agencies. The Dutch example is an excellent illustration of the effect of enlightened social policy on the control of infectious disease. (Beaujean *et al.* 1999, Verhoef *et al.* 1999)

M.R.S.A. is just one of many pathogens that have acquired resistance to antimicrobial therapy. Although the resistant nature of these pathogens is intrinsically linked to antibiotic use, their control is dependent on recognition of the larger societal factors that contribute to their spread. Institutionalization of education, health care, and care of children and the elderly has been a significant factor in the maintenance of a reservoir of infectious disease. Increased mobility ensures that infectious pathogens have access to all areas of the globe. Its prevalence in large urban centres implies a connection between M.R.S.A. and the geographic and environmental factors which characterize Western cities. Through the processes of industrialization and urbanization that have accompanied the Classical (Western) epidemiologic transition, concomitant social, political and environmental factors have developed which ensure infectious pathogens a secure hold on their human hosts.

I am not such a pessimist as to suggest that the emergence of M.R.S.A. constitutes the next global pandemic. However, I am suggesting that the conditions of M.R.S.A.'s emergence are part of the social, political and environmental climate of the industrial West. Within this climate are numerous factors which foster the potential re-

emergence of infectious disease as a leading cause of death, a process which characterizes the earlier stages of Omran's epidemiologic transition.

Unlike many diseases, M.R.S.A. threatens not only the marginalized groups at the lower end of the socioeconomic scale, but the affluent consumers of costly health care. Perhaps this fact may induce Western nations to adopt the social policies necessary for its control. Public education, community screening, epidemiologic vigilance and careful attention to marginalized and institutionalized populations are urgently required. However, such a commitment to public policy will require a fundamental shift from the individualist ethos which guides much of Western political action. The identification of ourselves as 'individuals' has contributed substantially to the re-emergence of infectious disease as a significant cause of morbidity and mortality. Infectious diseases are by nature collective in their epidemiology, and therefore require a collective approach to their management and control.

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