

# Lessons from Semmelweis: A Social Epidemiologic Update On Safe Motherhood

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## Abstract

In this historical review, Ignaz Semmelweis' study of handwashing to prevent puerperal fever is described and used as a benchmark from which to identify salient issues that are informative to today's women's health activists working for Safe Motherhood. The epidemiology of contemporary excess maternal mortality is reviewed. Using the conceptual framework of social epidemiology, the paper addresses four issues that were problematic in Semmelweis' era. New tools in public health are presented that can help to solve critical, still challenging problems to reduce excess maternal mortality, nosocomial infections, and puerperal fever at childbirth: 1) progress in behavioral methods to promote health behavior change, 2) the introduction of participatory action research, 3) the diffusion of evidence-based public health practice and 4) understanding how politics and health interact and present challenges when trying to meet public health goals. Social exclusion and marginality are still key issues in determining who has access to safe motherhood and who risks her life in maternity. Applied social epidemiology allows practitioners to make effective use of the already accumulated evidence and translate it into effective public health practice to promote safe motherhood around the world.

## Introduction

One stratagem for promoting public health is to separate noxious infectious agents and susceptible hosts. When the agents are nosocomial infections carried on the hands of health practitioners (the

human transmission vector) who inadvertently infect their patients, then a change in behavior is required, challenging behavioral science and social epidemiology to prove their efficacy.<sup>1 2</sup> The quintessential study in social epidemiology occurred in Vienna in 1847 when Dr. Ignaz Semmelweis (1818-1865) introduced institutional and behavioral guidelines for handwashing in order to reduce the rate of puerperal fever among women delivering in the Obstetrical Clinic in the Vienna General Hospital, the Allgemeines Krankenhaus. Semmelweis took an interventionist stance and applied his correct interpretation of numeric data to change the behavior of his fellow physicians within a medical organization. Research, in this case, was challenged to prove its value in the real world by taking "robust evidence" and translating it into an effective public health policy. In this way the science and the art of public health practice were combined.<sup>1</sup> These events took place in a loaded social context which ultimately compromised the dissemination of Semmelweis' experiment. In this paper, the clock is turned back to deconstruct Semmelweis' experiment as a baseline incident from which to evaluate advances made in public health that are still germane to reducing maternal morbidity and mortality in our day. Examples are drawn from international sources and derive from the field of women's health, as did Semmelweis' work.

Women's health and gender-based medicine combine biological factors associated with health status usually termed "sex" (biological classification as either male or female) together with "gender" (self-representation as male or female that is shaped by both exposure to economic, social and cultural factors and reinforced by experiences with the environment).<sup>3-</sup>

<sup>5</sup> The interaction of sex and gender are powerful

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determinants of health status, morbidity, access to services and mortality.<sup>6-16</sup> Understanding the contribution that gender makes to health and its interaction with both biology, health care, and social patterns has been a potent theoretical and methodological tool in current social epidemiology.<sup>2</sup> A parallel process in social epidemiological theory has used this type of "gendered lens" to examine how discrimination, social exclusion, disenfranchisement through social inequalities, immigrant or refugee status or belonging to an ethnic minority affect health.<sup>17-25</sup> Often these processes interact to produce groups of women whose health is disadvantaged by the intersection between gender, poverty, and/or minority or immigrant status, a process that is particularly tragic in respect to maternal health. There is no public health indicator that shows as great a gap between rich and poor as maternal mortality.<sup>26</sup> Excess maternal mortality is still concentrated in the developing world and in places in the developed world where inadequate health care systems interact with health inequalities to limit social and health rights for girls and women.<sup>26-28</sup> We return to these issues in the body of this paper.

The interaction between gender-based health issues and social marginality are salient in Semmelweis' story as well. This historical overview of Semmelweis' life and accomplishments points to those public health methods that offer new tools with which to develop a more effective response to maternal morbidity and mortality in today's world.

**Ignaz P. Semmelweis, M.D (1818-1865):  
"Prophet of Bacteriology", "Father of  
Antisepsis", "Savior of Mothers" and "Tragic  
Hero" (all rolled into one)<sup>29-32</sup>**

Semmelweis' study and its contribution to the control of nosocomial infections by hand hygiene in the workplace have gripped the imaginations of public health and medical researchers for the past century and a half, an interest which continues unabated to this day.<sup>35-44</sup> Preventing nosocomial infections in childbirth still challenges today's clinical settings, and Semmelweis' findings are taught across continents, cultures, and professions including midwifery, surgery, biostatistics, obstetrics/gynecology and public health, appearing in many languages.<sup>30-32,45-52</sup> While Semmelweis'

story is well known, a brief review is included here.

Ignaz Philipp Semmelweis, M.D. (or Ignác Fülöp Semmelweis ) was born in 1818 in Taban, part of Buda, Hungary. In 1837, he came to study medicine at the University of Vienna. A contemporary of John Snow (1813-1858), he spent 15 months studying diagnostic and statistical methods under Josef Skoda (1805-1881), who was a student of Pierre Charles-Alexandre Louis (1787-1872).<sup>53</sup> Louis had fostered the numeric method in medicine through the judicious use of statistics and had trained many luminaries of early public health including William Farr, John Simon, Joseph Skoda and the American leaders Lemuel Shattuck and Oliver Wendell Holmes.<sup>54</sup> Following the completion of his studies, in 1846, Semmelweis became the assistant to Johann Klein (1788-1856), chief medical officer of the First Obstetrical Clinic at the Vienna General Hospital, the Wein Allgemeines Krankenhaus.

The Allgemeines Krankenhaus was a public lying-in hospital established primarily to train physicians in obstetrics and particularly in forceps delivery.<sup>40</sup> Services were primarily for poor women who could not afford the expense of a private midwife or obstetrician. Many of them were foreigners, immigrants, and mothers birthing out of wedlock. The large number of deliveries offered the ideal teaching environment and many medical students came to the General Hospital for clinical practice. The stench that rose from the crowded general wards from the mixture of expectorant, blood, pus, and excrement was deemed unhealthy according to the current miasmatic theory and the lying-in wards were therefore separate from the main hospital.

Under the previous director, Lucas Boër, the maternal mortality rate of the obstetrical department had been 1.25% over the course of 71,000 patients. Boër had taught using a dummy mannequin to show the female anatomy. However, when Johann Klein took over the post, he instituted the innovation of teaching through post-mortem demonstrations, which were not attended by the midwifery students. Klein reorganized the department into two wards, one training students in midwifery, the other a ward for medical students. The rate of puerperal fever, or childbed fever due to wound infection (the major cause of maternal mortality), rose in the

wards staffed by the medical students. Between the years 1841 to 1846, maternal mortality averaged 13-17%, reaching between 20-50% during epidemic periods. In the midwives' ward the mortality was stable at 1.5%.<sup>35,40,53-56</sup>

Semmelweis observed that most of the hospitalized pregnant women contracted childbed fever even before delivery, and that the point of infection was always the uterus. Furthermore, puerperal sepsis was rare in women who had already delivered before arrival at the hospital. However, the chains of inference only clicked in Semmelweis' mind on reading the autopsy report of his friend and colleague, Jakob Kolletschka, a professor of pathology who died of "pathologist's pyemia" - an accidental wound to the hand after an autopsy.<sup>53</sup> The frequent attendance of the medical students at autopsies suggested to him that the transfer of cadaverous material might be the source of the rampant childbed fever.

He would later write of Kolletschka that "His sepsis and childbed fever must originate from the same source ... the fingers and hands of students and doctors, soiled by recent dissections, carry those death-dealing cadavers' poisons into the genital organs of women in childbirth"<sup>56</sup> [p. 669 quoting from reference 33].

Up until now, Semmelweis' scientific discovery parallels that of British physician Alexander Gordon (1792), Thomas Watson, an obstetrician (1842), and Dr. Oliver Wendell Holmes, the Boston pathologist who published "The Contagiousness of Puerperal Fever" in 1843 (including the recommendation to avoid autopsies if possible).<sup>40,54,56</sup> However, Semmelweis carried his findings one step further. Starting from 1847, all doctors and students were ordered to wash their hands in chlorinated lime solution before working in the delivery wards and after each vaginal examination. The rate of "pyemia", as he termed the condition, fell from 18% to less than 3% in a matter of months.

He wrote of his experiment in 1847:

*"In the first four months of the year, thirty to forty deaths per month were counted. Toward the end of May the washings were introduced, and from that time the cases of illness, which otherwise occurred daily, ceased. In June three died, in July, the same number; and until mid-August, two. At that time a new group of*

*students was admitted. Some of these neglected the washings, and by the end of August, twelve patients had died. After stricter control with regard to washings, the morbidity afterwards ceased, so that to the end of September only three deaths occurred. ...in the absence of other evidence which might explain the remarkable decline in childbed fever noted in this hospital, the above-mentioned cautionary regulations concerning examinations greatly deserve attention and may encourage similar experiments in other maternity hospitals." pp. 256-257<sup>55</sup>*

In this description, we find both the strength of Semmelweis' insights; a numeric count of cases over months before and during the experiment and also a reference to a major barrier to the diffusion of Semmelweis' innovation. The new students who joined the medical team were not sufficiently inculcated in the importance of this time-consuming practice, and they were intermittently compliant with the suggested regulations. Furthermore, the hospital administration did not endorse hand washing, meaning that Semmelweis was required to reinforce the practice in order to achieve the desired reduction in maternal mortality.

Semmelweis, perhaps lacking confidence due to his own position as a foreigner in Vienna, was reluctant to publish his findings, which were presented at a lecture by Professor Hebra in 1847 and later by Skoda in 1849. Noting mistakes in their renditions, Semmelweis finally presented his own results in 1850 to the Association of Physicians in Vienna. His ideas were met with derision by leading scientists and physicians – ironically enough including the pathologist Rudolph Virchow<sup>1</sup> (1821-1902). The conclusion that physicians in general and his supervisor Professor Klein in particular were the source of

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<sup>1</sup> Virchow is considered by Rosen as the first social epidemiologist by virtue of his multi-causal approach to understanding health and illness that he forged in his observations of the Silesian typhus epidemic. He maintained that only a combination of biological, social, economic and political social forces adequately explained infectious disease. He was an ardent advocate for social medicine. His words "Medicine is a social science and politics nothing but medicine on a grand scale" are often a rallying cry for reform in public health. (Rudolph Virchow p. 62, reference 54)

iatrogenic illness<sup>2</sup> was galling to the medical establishment.<sup>40,41</sup>

In 1849 his contract under Klein was not renewed. Humiliated and discouraged he abruptly left Vienna in 1850 and thus slammed the door to academic recognition for his work even among his friends and supporters.<sup>53</sup> Back in his own territory, he established a private practice and obtained an appointment at the University of Pest. He continued to collect data, eventually published his findings in 1857 and in 1861 in a book entitled "The Etiology, the Concept and Prophylaxis of Childbed Fever".<sup>58</sup> But Semmelweis lacked both laboratory findings and access to other publications in his area in order to sway his detractors (being unaware of the publications in English on the same topic by Holmes and Watson). He attacked his critics in open letters in 1861-1862 but recognition eluded him and he fell into despondency. In 1865 he was committed to an insane asylum, where (depending on the version of the story) he turned violent and was beaten into submission and died of his injuries<sup>59</sup> or suffered an infected finger and died of sepsis.<sup>54,56,60,61</sup> Regardless of the exact cause, whether from infection, violence or depression, Semmelweis' untimely death cut short a brilliant scientific career.

Four aspects of Semmelweis' story represent stumbling blocks that prevented his findings from acceptance and dissemination at the time and are still major challenges in tackling excess maternal mortality in our day: 1) the lack of understanding of how difficult behavior change is in general and among health practitioners in particular; 2) research methods that allow for the voice of affected parties or their advocates to shape research and practice; 3) the lack of a consensus in the medical community on how research into medical practices should be conducted; and 4) the lack of understanding about the power that social exclusion and marginality can have on decision-making and access to health care resources, a phenomena common both to "outsiders" and to women. These issues are presented as "lessons for women's health" with respect to puerperal fever (sepsis) and reducing excess maternal mortality, cloaked in their modern equivalents and presented in roughly chronological order of their

appearance in public health practice: 1) development of behavioral methods to promote health behavior; 2) the introduction of participatory action research and other qualitative methods that give a voice to disenfranchised and marginalized populations particularly affected by excess maternal mortality; 3) the diffusion of evidence-based public health practice; and 4) understanding of the role of politics and social inequality in setting public health priorities. First, however, the global epidemiological picture on excess maternal mortality is presented.

### **Maternal Mortality – The Global Picture**

Despite twenty years of focused programs around the world following the adoption of Safe Motherhood Initiatives in 1987, little tangible progress has been made in preventing excess maternal mortality. The distribution of excess maternal mortality is skewed so that of the 600,000 deaths that occur annually from complications of pregnancy and delivery, 99% of them are in the developing world.<sup>26,62</sup> Recognizing this chronic situation, the United Nations included reduction of maternal mortality as one of the 10 Millennium Development Goals (MDGs) to address global extreme poverty. The quantifiable target was to reduce maternal mortality by 75% relative to its 1990 level.<sup>63</sup> Death from maternal causes represents the leading cause of death for women of reproductive age in developing countries and contributes 2/3s of the world disease burden of total DALY's (disability-adjusted life years) lost due to reproductive ill-health in this age group. Furthermore, at least 2/3 and possibly 3/4 of these deaths could be prevented by empirically based cost-effective interventions.<sup>64</sup> According to a recent analysis, over 60% of excess maternal deaths occur in just 10 countries in African and Asia<sup>3</sup> and sepsis still remains one of the leading causes of mortality.<sup>27,65,66</sup> Where data has been disaggregated in developing countries, puerperal sepsis is still one of the leading causes of maternal mortality, together with hemorrhage, hypertensive disorders, and abortion.<sup>65-72</sup> We return to this issue later in the paper when the issue of social exclusion is discussed.

<sup>2</sup>The word iatrogenic was only coined in 1924.<sup>57</sup>

<sup>3</sup> Djibouti, Burkina Faso, Ethiopia, Eritrea, Angola, Guinea-Bissau, Chad, Yemen, Sierra Leone, and Niger.

## **Advances in Social Epidemiology to Address Maternal Mortality**

Social epidemiology incorporates diverse sources of data, both qualitative and quantitative into a comprehensive framework leading to the development of empirically-based interventions, programs, community initiatives, and national and global health policy.<sup>2</sup> By looking at both proximate and distal influences on health using the epidemiological triangle of host, agent and environmental risk and protective factors, social epidemiology provides guidelines for how to apply what we already know to make a difference in maternal mortality.<sup>2</sup> This is demonstrated through four developments in public health that were lacking in Semmelweis' time.

### **Lesson 1: Adopting effective methods for behavioral change**

In the 150 years since Semmelweis' experiment, a great deal has happened to improve both the art and the science of behavior change interventions in health care. One of the unique contributions of public health practice is in promoting behavior change to improve health status through both primary and secondary prevention<sup>73</sup> and through the creative use of multi-level strategies or ecological models for health promotion.<sup>74-76</sup> A great deal of effort has been invested over the last fifty years in developing effective strategies of individual, group, and community interventions to promote health, which have also been applied to improving outcomes in maternal health (see e.g. references 75 & 77). Public health practitioners can now choose among an array of theoretical models to affect behavioral interventions including The Health Belief Model, stress theories, cognitive-behavioral therapy, Theory of Reasoned Action, and the Transtheoretical model both in preventive interventions<sup>78-80</sup> and with persons already affected by a health problem.<sup>79,81-84</sup>

How can this knowledge about effective behavioral change give the activist practitioner a better chance of success in preventing nosocomial puerperal sepsis? These studies have led to the understanding that within hospital settings educational measures alone, particularly if they are simply didactic, have little to no effect on hand washing or other hygienic behavior. However,

coupled with feedback and performance review, the target behavior is significantly increased.<sup>85-87</sup> Effectiveness is further enhanced where there is organizational reinforcement including: reduction in work load, administrative support, clear hospital policy in support of hand washing, and a change from soap and water to alcohol-based rubs.<sup>88,89</sup> In one study, the establishment of inter-hospital focus groups gave broader support to organizational changes at the individual hospitals.<sup>87</sup> There may be a need to tailor change strategies for specific professional groups. For example, nurses are more successful at hand hygiene than physicians and physicians in training.<sup>44,90,91</sup>

Hand-washing among health care staff is a core behavior in the control of all nosocomial infections and together with other practices (use of masks and gowns) was recently in the international limelight following the high rate of SARS infection among hospital staff members who had treated infected patients.<sup>43,92</sup> As with the HIV epidemic, medical practitioners were much quicker at adapting to hygienic practices when their own personal safety was endangered.

There have been several reviews of how to successfully implement improvements in medical practice. The most consistent findings are: simple dissemination of information rarely is sufficient to change behavior; outreach, feedback, performance audit and use of opinion leaders is sometimes effective; and multiple interventions using several strategies and reminders are consistently most effective.<sup>93-98</sup>

Two research advances have been critical in providing scientific evidence unavailable in Semmelweis' time: 1) the ability to quantify behavior as part of research, and 2) to combine different levels of evidence including the reduction of infections using counts of nosocomial colonization, together with knowledge and behavioral indicators.<sup>44,85,86,99</sup> Examples of this ability to combine behavioral self reports and laboratory counts of pathogens are apparent in the work of Rotter and colleagues who have conducted research over many years at the Hygiene Institute at the University of Vienna to test which compound is the most effective in reducing counts of pathogenic organisms on hands of medical practitioners.<sup>88,89,100,101</sup> Rotter too recognized Semmelweis' observation that hand

washing with soap and water was less effective than other compounds such as alcohol-based rubs and that compliance with hand hygiene is still problematic in most settings.<sup>88</sup>

One contemporary study enlisted close to 7,000 women about to give birth in a busy, tertiary care urban hospital in Malawi.<sup>102</sup> Two months of data were collected on women and their infants under usual prenatal practices and then compared with outcomes during a three month intervention period when special washing routines were instituted using a mild solution of 0.25% chlorhexidine in sterile water. The trial ended with a final month of no intervention. The chlorhexidine washes were effective in reducing both post-partum infections and infant mortality by a factor of three.

## **Lesson 2: Learning Directly from Health Practitioners in Developing Countries where Maternal Mortality is Highest**

As Maharaj has noted, the infectious agent of puerperal infection at childbirth has three sources: nosocomial (acquired in hospitals or clinics through iatrogenic processes), exogenous (through infections acquired through external sources especially when deliveries occur under unhygienic conditions such as in home births), and endogenous (mixed infections including colonization by flora from the women's own urogenital tract).<sup>103</sup> Aside from treatment with antibiotics for those infections that do arise, education of hospital, home birth attendants and community health care workers is critical in preventing maternal morbidity and mortality. Thus, the site of health promotion efforts to reduce excess maternal mortality should not be limited to the hospital setting, but needs to focus on involving health care practitioners at the community and village level as well.

Community-based participatory action research (CB-PAR) combines a research and intervention process to address problems in health through a critical reflection on the contributing context.<sup>104-106</sup> This research paradigm was first proposed by Lewin in the 1940s, drew theory and analytic tools from phenomenology, and was further developed by Paulo Freire who worked with disenfranchised populations and later through empowerment practice methods in health that diffused Freire's ideas.<sup>107-114</sup> The participatory process facilitates

the acquisition of knowledge which is critical in changing the balance of power from the experts (particularly those with medical authority or research capacities) to include those affected by the health issue. For this reason, participatory action research or empowerment practice is particularly suited for underserved, disenfranchised populations, as well as women in developing countries – often the population groups most affected by excess maternal morbidity and/or the population of health care practitioners giving care to women.<sup>115-117</sup> Furthermore, the use of other qualitative methods such as focus groups, ethnography, and qualitative interviewing can help to represent their "voice" in the health issue.<sup>118</sup>

CPR has been particularly effective in encouraging the service use of black or Latina women in the US or those who live in rural areas.<sup>119-123</sup> Furthermore, to improve services for maternal care in delivery, particularly in developing countries, CB-PAR can encourage better data collection, monitoring of health outcomes, and developing practical solutions to pressing health problems.<sup>124-129</sup> These strategies are suitable also for inner cities, rural areas, and underserved populations in developed countries as well.<sup>110,130-136</sup>

Despite concerted efforts in Safe Motherhood programs, such as initiatives promoted by the WHO, international women's health agencies, and NGOs<sup>137</sup>, accumulated knowledge has not yet sufficiently changed health care systems in many developing countries to enable them to successfully prevent avoidable maternal deaths.<sup>62,65,138,139</sup> Analysis of cases of maternal death show they are often due to delay in seeking treatment, transportation problems, failure of medical staff to adequately treat infectious conditions or to target high risk groups of women with low educational attainment and unmarried status.<sup>65,66,69,102,140,141</sup> Safe Motherhood successes have been achieved in countries such as Egypt where maternal mortality was reduced by half in the past decade through improved service delivery and Bolivia which introduced national health insurance to improve service delivery to women.<sup>142</sup> The successes of Malaysia, Sri Lanka, Bolivia, Thailand, Chile, Columbia, Honduras, and Nicaragua in reducing maternal mortality by half within a decade attest to the ability of

developing countries to make real inroads in reducing excess maternal mortality if the political will is harnessed to do so. These experiences provide successful case studies to be emulated by other countries.<sup>143</sup> The WHO Making Pregnancy Safer (MPR) Initiative has recognized the importance of women-led activity with individuals, families, and communities and has produced a guide for health care practitioners which is available at the referenced URL<sup>4</sup>

In the United States, Safe Motherhood Initiatives, USA, sponsored the "Safe Motherhood Quilt Project" to focus attention to the low relative ranking (21<sup>st</sup> among the developed countries together with Slovenia and Portugal) of the US with regard to maternal mortality. The Safe Motherhood Quilt, a project started by Ina May Gaskin, President of Midwives Alliance in North America, commemorates the life stories of American women who have died of preventable causes of death associated with a complications of pregnancy or childbirth since 1982.<sup>144</sup> This project helped create the impetus for research that showed that maternal mortality is higher among women of color, immigrants, unmarried women, older women, and those who birth many children. The CDC has developed a national program of research and intervention in order to try to bring down the maternal mortality rate which has not declined since 1982.<sup>145</sup> Even in nations such as Australia with overall low rates of maternal mortality<sup>5</sup> (9 per 100,000 live births), cases are over-represented among indigenous women at about 4 times the expected rate.<sup>146</sup> Clearly there are still challenges for both developing and developed nations in order to reduce preventable causes of maternal mortality.

A review of approaches by community organizations working for women's health promotion in international settings showed that those that were successful improved women's access to services including reproductive and family planning, explicitly addressed gender issues, including gender-based violence, set

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<sup>4</sup> (<http://www.who.int/reproductive-health/mpr/communities.html>)<sup>142</sup>

<sup>5</sup> The intersection between ethnic minority and gender is expressed in all-cause mortality for Indigenous women whose rates of excess mortality for a variety of causes range between 3-5 relative risk ratios, such that maternal mortality is in this expected range.<sup>146</sup>

obtainable goals, and enhanced the status of women.<sup>117,147</sup> Three examples are:

1) community health workers in Tanzania collected data on the methods available for providing transportation for women during obstetric emergencies and suggested appropriate strategies in order to reduce the extremely high maternal death rate (300 times the rate in Northern Europe).<sup>148</sup> This led to a project where village health workers increased their knowledge of maternal danger signs, appropriate referrals, and increased use of transport to get pregnant women to the hospital.<sup>148,149</sup> While health care improved for pregnant and birthing women, this study did not directly assess maternal and infant morbidity and mortality.

2) Another study used participatory data collection in the community to evaluate the state of women's health in North Belfast – an area that had been troubled by internecine violence. This study revealed problems that needed addressing including risky access to services that were outside of safe political boundaries.<sup>150</sup>

3) A third program was also implemented in Tanzania and used a participatory process to establish an effective collaboration between representatives of an international reproductive health agency, the Ministry of Health and local professionals in order to improve reproductive and maternal health care quality. Local stakeholders were encouraged to collect data directly from women in order to present their needs for reproductive care services and to articulate their needs as staff persons with the goal of building sustainable capacity. This led to the development of a means for monitoring and evaluation called COPE that improved the quality of care for maternal health by 25%.<sup>151</sup>

### **Lesson 3: The growth of evidence-based medicine**

One of the problems that Semmelweis faced was that physicians and hospitals were governed by practices developed through experiential learning often divorced from accumulated scientific research. Semmelweis was trained by Skoda in the best epidemiological research practices of his time, but this was by no means standard in medical training. However, the rise in evidence-based medicine (EBM) and evidence-based public health practice (EBPH) has offered a

powerful counterbalance for those who wish to introduce behavioral or organizational changes in the delivery of health care.<sup>152-158</sup> Thus, if there is a commitment to examining iatrogenic sources of maternal morbidity and mortality, EBM is a powerful tool for health promotion.

The roots of the current trends in EBM started in the early 1980s with the vigorous application of epidemiological principles to medical practice, particularly as practiced at McMaster University.<sup>159</sup> Eventually both through voluminous publications (e.g. references 153, 160, 161) – including textbooks – the approach gathered support from both clinicians and public health professionals.<sup>162</sup> EBM is defined as the judicious use of current evidence from health care research in decisions about the care of individuals and populations.<sup>162</sup> EBM is a persuasive and reliable method for analyzing current practices and introducing improvements in health policy.<sup>79,163-167</sup> The tools of EBM need not be restated here and are widely available, but one issue is of importance: grading the quality of evidence. This gives the blue-ribbon to the randomized-controlled trial (RCT), moving through quasi-experimental evidence and descending down the ladder of confidence to descriptive and case observations. Evidence is compiled and distilled, aided by access to electronic databases, ideally through systematic meta-analysis, such as in the Cochrane Reviews.<sup>2,168,169</sup>

However, the gold standard of RCT has been subject to criticism for its exclusionary nature and for the fact that many toxic or acute conditions (myocardial infarction, bleeding at childbirth) or exposure to ecological disasters such as Chernobyl or Bhopal can not be randomly assigned; these can be studied only by observation of the natural experiments as they occur. Thus, a recent review concluded that " a well-designed non-randomized study is preferable to a small, poorly designed and exclusive RCT."<sup>170</sup> Those who participated in RCT of clinical treatments tended to be less affluent, educated and more severely ill than other patient groups, thereby possibly exaggerating the treatment effect. However, those who participated in RCTs of preventive interventions tended to be more affluent, educated and healthier than their reference population, possibly underestimating the treatment effect.<sup>170</sup> Often minority groups or non-English speaking persons are not included in

clinical trials, thus effectively barring them from treatment improvements.<sup>169</sup>

However, while touting this as the ideal in medical education and training, there exists to date no evidence that practitioners using EBM will provide superior patient care compared with practitioners who practice using fundamental medical education and their own clinical experience. Ironically, running an RCT is deemed unethical as the comparison group could not be deprived of the medical knowledge that informs the physicians or practitioners in the experimental condition.<sup>171</sup> Furthermore, the EBM paradigm has now matured into a method that can tolerate questions, recognizing that findings derived from observational studies often agree<sup>6</sup> with the more prestigious RCT findings<sup>173,174</sup> and that RCTs are not always ideally designed and carried out.<sup>170</sup> Thus, coping with ambiguity by retaining a questioning stance can help to preserve perspective, something that Semmelweis lacked in his time.

Other problems in successfully evaluating intervention research are also recognized by EBM practitioners: the importance of patients' preferences in selecting treatments, the wide variation in treatment settings – some rich in resources and others bleak in their access to basic facilities.<sup>175</sup> Maternal and cultural preferences for certain health care practices (e.g. rooming-in, breastfeeding, attendance by husbands at childbirth) should be taken into consideration when applying EBM principles to studies of how to make service delivery more effective and safer. While providing scientific criteria and a basis for evaluating scientific studies, EBM requires an understanding of its limitations in order to be an effective tool for promoting women's health and reducing maternal morbidity and mortality.<sup>176</sup>

Returning again to the issues of preventing excess maternal mortality, there are a few exemplar programs that demonstrate the application of EBM research designs. One RCT in Zimbabwe tested the efficacy of providing fewer, focused, goal-oriented antenatal care visits (4 visits) compared with the standard program of

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<sup>6</sup> Clearly this is not always the case. For example, antioxidant vitamins were found associated with lower risk of cardiovascular disease but evidence from RCTs however failed to show a consistent effect.<sup>172</sup>

antenatal care (6 visits).<sup>177</sup> The more focused but reduced-visits program was as effective in terms of perinatal and maternal morbidity and mortality as standard care suggesting ways of making health care systems more resource effective, a finding of particular importance in developing countries. These findings have now been replicated in a multi-country RCT conducted by the World Health Organization (WHO).<sup>178,179</sup>

The proportion of attended births by skilled health care practitioners is a major determinant of both maternal and infant mortality in the developing world.<sup>180</sup> Every year, 60 million women in the developing world give birth at home without any professional health care attending the birth.<sup>181</sup> Globally, this translates into 63% of births attended by a skilled health-care practitioner.<sup>180</sup> Doctors, nurses, midwives, and alternative health-care providers can acquire the skills to provide a clean, safe delivery in routine situations and to identify complications in need of emergency obstetrical care. As an interim step in the reaching the MDG, the proportion of attended births has become a health-care indicator.<sup>180</sup> One study in rural Indonesia evaluated a program to train, deploy, and supervise professional midwives in villages. The proportion of attended births rose from 37% to 59%, however there was no increase in the proportion of women receiving emergency obstetric care, possibly because of the cost involved.<sup>182</sup> The participation of the midwives in the maternal and perinatal audit of complicated cases increased their confidence in their professional skills.

One quasi-experimental design in the Matlab area of Bangladesh evaluated the introduction of a maternity care program of training and posting professional midwives in villages and the establishment of a backup referral system. The first three years of data showed a significant decline in maternal mortality in the intervention areas compared to the control areas.<sup>183</sup> However, a longer term evaluation showed that the declines in maternal mortality were also observed in an area not receiving the midwifery program, suggesting that caution must be used in the interpretation of the data.<sup>184</sup> Another clinical trial tested the procedures to screen pregnant women in order to identify those at high-risk in need of hospital delivery. However, a similar proportion of those classified as high risk using traditional risk

markers developed complications at delivery as those who were not designated at high risk (20% vs. 18%).<sup>185</sup>

An example of a community program that combined many types of interventions in order to promote maternal and infant health was reported from Natal, in the Northeast of Brazil. The interventions included: establishment of antenatal care clinics, the opening of maternity wards in the community for low-risk deliveries and the integration of services with family-planning, breast-feeding support, pediatric services, and the implementation of a community health activist to make home educational visits. Two health surveys – pre and post intervention – indicated that the innovations were successful in promoting attended births and reducing both maternal and infant mortality.<sup>7</sup> However, the many components of this comprehensive community program make it unsuitable for evaluation using a RCT design while its success in achieving better maternal health make it a valuable case study in a developing country.

#### **Lesson 4: Social exclusion – when politics interact with public health**

Semmelweis' status as an outsider in Vienna no doubt contributed to the difficulties he encountered. While he received professional recognition in his work in Pest, Hungary, the soundness of his recommendations on the prevention of puerperal fever was never accepted by his contemporaries who read the German-language medical journals.<sup>186</sup> His experiences can be compared with the success of John Snow's experiment in cholera prevention (which passively induced change by removing the Broad Street pump). However, Snow's position as attending physician to Queen Victoria certainly enhanced his status and ensured a fair hearing of his research findings.<sup>8</sup> Semmelweis' story

<sup>7</sup> Although the numbers of maternal mortality were so small that this estimate may not be stable – 4 deaths in the pre-intervention period to 0 in the post-intervention period.

<sup>8</sup> For historical perspective, the policy findings of James Lind's (1716-1794) experiments from 100 years earlier on the appropriate treatment for scurvy that decimated the ranks of English seamen was only adopted as official British navy policy in 1795, 40 years after he had published his findings (1753).

emphasizes the difficulties inherent in vertical top-down decision making in health care, when new ideas are suppressed in favor of the status quo. This review has shown that both organizational support from hospital administration *and* the involvement of health care practitioners and community public health advocates builds the most successful coalitions for change.

Returning to contemporary issues in addressing the challenges of reducing excess maternal mortality, we find that often political considerations and not evidence-based public health set the agenda and that most of the burden of excess morbidity and mortality falls on women from developing countries that do not have an adequate voice in international health decision making. Remember that the women who were hospitalized in Semmelweis' wards were marginalized women who could not afford their own private midwives to birth more safely at home.

Despite the clear connection between reproductive health, family planning services and maternal mortality, the bulk of the funding for family planning and reproductive health has been shifted to halting the spread of HIV.<sup>187</sup> Those developing countries who have been successful in decreasing maternal mortality have coupled maternal health services with easily accessible, community-based family planning.<sup>188</sup> As much as 20-35% of excess maternal mortality could be prevented simply by ensuring access to family planning in order to allow women to have the number of pregnancies they desire.<sup>64,187</sup>

On President George W. Bush's first day in office he reinstated the Mexico City policy of former President Ronald Reagan, effectively cutting-off all US financial assistance for foreign NGOs providing abortion services, including counseling and referral. This was somewhat mitigated by a resolution adopted by the WHO in 2004 which reinstated the legitimacy of reproductive and family planning health services as a means of reducing maternal mortality and included them in the list of "quick wins" in the health sector.<sup>63</sup> The evidence shows that most of the nearly 20 million unsafe and unsanitary abortions performed by persons without adequate medical skill are carried out in the developing world, where they cause almost 70,000 deaths a year from hemorrhage and infection. The

prevalent social inequality of women in the countries that prevent access to safe abortions led the authors of a recent study to declare that apathy and disdain toward women are at least as much a causal factor in explaining this excess mortality as infection from unsanitary conditions.<sup>28</sup>

As Graham and Hussein point out, progress in reducing maternal mortality depends on being able to collect reliable data to document changes and improvements in maternal care. Yet, particularly in countries where maternal mortality is the highest, the data on maternal mortality are woefully inadequate and linked to the social disenfranchisement of women in determining their health and reproductive needs. "The invisibility of maternal death and disability is not just a matter of failing health information systems. It is also a symptom of constraining social environments in which rights to life, health and reproductive autonomy are forbidden for most girls and women."<sup>27, pg. 2</sup> Thus, safer motherhood requires a concerted collaboration between community health workers, public health activists, and medical researchers together with national and international agencies to make judicious use of the knowledge we already have in order to make sure that women do not need to risk their own lives in order to give life.<sup>147,189</sup>

## Conclusions

This historical review of the problems encountered in Semmelweis' behavioral interventions with medical students and physicians has led to the discussion of four critical developments in the social epidemiology of women's health. Since the first behavioral clinical trial took place in Vienna more than 150 years ago, there has been significant progress in the science of behavioral interventions in general and among health care practitioners in particular. However, people in power still have difficulty in seeing how political agendas, unsupported by scientific evidence can influence their own practice or prevailing health policies which may in turn, adversely affect their patient populations.

This paper argues that when health researchers critically use the tools of social epidemiology through effective behavioral change, evidence-based medicine and CB-PAR, they stand a good chance in achieving public health goals that can benefit maternal morbidity and mortality and other

areas of women's health as well. The lessons reviewed here are major research and practice principles that can inform current epidemiological practice in women's health and help to generate public health particularly for the benefit of "women at the margin" and in the developing world.

Many challenges remain in reducing excess maternal mortality, some resonate from Semmelweis time and others are more recent health developments. Using the tools presented here, honed over time with high quality research and a social commitment to public health activism, we can forge a more effective response to improving women's maternal and reproductive health.

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### Abbreviations used:

*CB-PAR* - Community-based Participatory Action Research  
*DALY* - Disability-adjusted Life Year  
*EBM* - Evidence based Medicine  
*EBPH* - Evidence based Public Health  
*RCT* - Randomized Controlled Trial  
*WHO* - World Health Organization

### References

1. Kasl SV, Jones BA. Social epidemiology: towards a better understanding of the field. *Int J Epidemiol* 2002;31(6):1094-7.
2. Cwikel JG. A textbook of social epidemiology - strategies for public health activism. New York: Columbia University Press, 2006.
3. Cottingham J, Fonn S, Garcia-Moreno C, et al. Transforming health systems: gender and rights in reproductive health. Geneva: World Health Organization, 2001.

4. Pollard T, Hyatt S. Sex, gender and health: integrating biological and social perspectives. In: Pollard T, Hyatt S, eds. Sex, gender and health. Cambridge: Cambridge University Press, 1999: 1-16.
5. National Academy of Sciences. Exploring the biological contributions to human health: does sex matter?: National Academy of Sciences - Open Book, 2000.
6. Kennedy J, Minkler M. Disability theory and public policy: implications for critical gerontology. *Int J Health Serv* 1998;28(4):757-76.
7. Macintyre S, Hunt K, Sweeting H. Gender differences in health: are things really as simple as they seem? *Soc Sci Med* 1996;42(4):617-24.
8. Johnson JV, Johansson G. Introduction: the need for new directions in research on work organization and health. *Int J Health Serv* 1989;19(4):721-4.
9. Aday L. At Risk in America. San-Fransisco: Jossey-Bass, 1993.
10. Amaro H, Hardy-Fanta C. Gender relations in addiction and recovery. *J Psychoactive Drugs* 1995;27(4):325-37.
11. Amaro H. Love, sex, and power. Considering women's realities in HIV prevention. *Am Psychol* 1995;50(6):437-47.
12. Doyal L. What Makes Women Sick: Gender and the Political Economy of Health. New Brunswick, New Jersey: Rutgers University Press, 1995.
13. Broome DH. Damned if we do: contradictions in women's health care. Sydney, 1991.
14. Verbrugge LM. How physicians treat mentally distressed men and women. *Soc Sci Med* 1984;18(1):1-9.
15. Verbrugge LM. The twain meet: empirical explanations of sex differences in health and mortality. *J Health Soc Behav* 1989;30(3):282-304.
16. Sen G, George A, Ostlin P. Engendering health equity: a review of research and policy. In: Sen G, George A, Ostlin P, eds. Engendering international health: The challenge of equity. Cambridge, MA.: A Bradford Book - MIT Press, 2002: 1-35.
17. Small R, Rice PL, Yelland J, Lumley J. Mothers in a new country: the role of culture and communication in Vietnamese, Turkish and Filipino women's experiences of giving birth in Australia. *Women Health* 1999;28(3):77-101.
18. Small R, Yelland J, Lumley J, Brown S, Liamputtong P. Immigrant women's views about care during labor and birth: an Australian study of Vietnamese, Turkish, and Filipino women. *Birth* 2002;29(4):266-77.
19. Raj A, Silverman JG. Immigrant South Asian women at greater risk for injury from intimate partner violence. *Am J Public Health* 2003;93(3):435-7.

20. Susser I, Stein Z. Culture, sexuality, and women's agency in the prevention of HIV/AIDS in southern Africa. *Am J Public Health* 2000;90(7):1042-8.
21. Ready T. Anthropology and the study of chronic disease: adolescent blood pressure in Corpus Christi, Texas. *Soc Sci Med* 1985;21(4):443-50.
22. Rich-Edwards J, Krieger N, Majzoub J, Zierler S, Lieberman E, Gillman M. Maternal experiences of racism and violence as predictors of preterm birth: rationale and study design. *Paediatr Perinat Epidemiol* 2001;15 Suppl 2:124-35.
23. Krieger N, Williams D, Zierler S. "Whiting out" white privilege will not advance the study of how racism harms health. *Am J Public Health* 1999;89(5):782-3; author reply 784-5.
24. Krieger N. Racial and gender discrimination: risk factors for high blood pressure? *Soc Sci Med* 1990;30(12):1273-81.
25. Krieger N. Epidemiology, racism, and health: the case of low birth weight. *Epidemiology* 2000;11(3):237-9.
26. Khan KS, Wojdyla D, Say L, Gulmezoglu AM, Van Look PF. WHO analysis of causes of maternal death: a systematic review. *Lancet* 2006;367(9516):1066-74.
27. Graham WJ, Hussein J. Minding the gaps: a reassessment of the challenges of Safe Motherhood. *AJPH* 2007;97(6):1-6.
28. Grimes DA, Benson J, Singh S, et al. Unsafe abortion: the preventable pandemic. *Lancet* 2006;368(9550):1908-19.
29. Wyklicky H, Skopec M. Ignaz Philipp Semmelweis, the prophet of bacteriology. *Infect Control* 1983;4(5):367-70.
30. Lange J. [Ignaz Semmelweis--"Savior of Mothers". Long fight for recognition]. *Fortschr Med* 1997;115(33):60.
31. Breido IS. [The discovery and tragedy of Ignaz Semmelweis (on the 140th anniversary of his discovery)]. *Akush Ginekol (Mosk)* 1987(4):73-4.
32. Breido IS. [Ignaz Semmelweis--forefather of antiseptics (on the 180th anniversary of his birth)]. *Vestn Khir Im I I Grek* 1999;158(2):83-5.
33. Sinclair WJ. Semmelweis: his life and his doctrine. Manchester: Manchester University Press, 1909.
34. Hegar A. Ignaz Philipp Semmelweis. Sein Leben und Seine Lehre, Zugleich ein Beitrag zur Lehre der feieberhaften Wundkrankheiten (German). Freiburg-Tubingen: Friebur im Breisgau, 1882.
35. Greenhill JP. Ignaz Semmelweis, Oliver Wendell Holmes and puerperal infection. *Int Surg* 1966;45(1):28-31.
36. Classics in infectious diseases. Childbed fever by Ignaz Philipp Semmelweis. *Rev Infect Dis* 1981;3(4):808-11.
37. Carter KC. Josef Skoda's relation to the work of Ignaz Semmelweis. *Medizinhist J* 1984;19(4):335-47.
38. Greenwald RA. Ignaz Philipp Semmelweis. *Med Herit* 1985;1(3):232-3.
39. Carter KC, Abbott S, Siebach JL. Five documents relating to the final illness and death of Ignaz Semmelweis. *Bull Hist Med* 1995;69(2):255-70.
40. Bridson EY. Iatrogenic epidemics of puerperal fever in the 18th and 19th centuries. *Br J Biomed Sci* 1996;53(2):134-9.
41. Riffenburgh RH. Reverse gullibility and scientific evidence. *Arch Otolaryngol Head Neck Surg* 1996;122(6):600-1.
42. Buyse M. A biostatistical tribute to Ignaz Philip Semmelweis. *Stat Med* 1997;16(24):2767-72.
43. Daniels IR. Historical perspectives on health. Semmelweis: a lesson to relearn? *J R Soc Health* 1998;118(6):367-70.
44. Hugonnet S, Pittet D. Hand hygiene-beliefs or science? *Clin Microbiol Infect* 2000;6(7):350-6.
45. Ignaz Philipp Semmelweis (1818-1865)]. *S Afr Med J* 1966;40(26):605-6.
46. Fisher M. [Ignaz P Semmelweis: forgotten hero]. *Harefuah* 1998;135(11):561-4.
47. Kraatz H. [Ignaz Philipp Semmelweis; 1 July, 1818-13 August, 1865]. *Zentralbl Gynakol* 1965;87(33):1137-40.
48. Lengyel E, Beric BM. [Midwives--students of Ignaz Philipp Semmelweis from the territory of Yugoslavia]. *Med Pregl* 1974;27(7-8):337-41.
49. Lesky E. [Ignaz Philip Semmelweis, legend and history]. *Dtsch Med Wochenschr* 1972;97(15):627-32.
50. Rihner F. [Ignaz Philipp Semmelweis (1818-1865)]. *Med Welt* 1981;32(51-52):1962-3.
51. Schmitt W. [Antiseptics and aseptics in changing times]. *Zentralbl Chir* 1979;104(10):625-30.
52. Venzmer G. [The physician Ignaz Philipp Semmelweis]. *Krankenpflege (Frankf)* 1972;26(2):57.
53. Enersen OE. Ignaz Phillippe Semmelweis. Who Named it?: whonamedit.com, 1994.
54. Rosen G. A History of Public Health. Expanded Edition of 1958 Publication ed. Baltimore, MD.: Johns Hopkins University Press, 1993.
55. Carter KC, Tate GS. The earliest-known account of Semmelweis' initiation of disinfection at Vienna's Allgemeines Krankenhaus. *Bull Hist Med* 1991;65:252-257.
56. De Costa CM. "The contagiousness of childbed fever": a short history of puerperal sepsis and its treatment. *eMJA* 2002;177(11/12):668-671.
57. Merriam-Webster Collegiate Dictionary. 11th edition ed: <http://www.m-w.com/home.htm>, 2003.
58. Semmelweis IP. The etiology, the concept, and prophylaxis of childbed fever - (German) -

- translated into English by F.R. Murphy. *Medical Classics* 1941 (1861);5:350-373.
59. Nuland SB. The enigma of Semmelweis - an interpretation. *J Hist Med Allied Sci* 1979;34.:255-272.
  60. Renaud M. [From social epidemiology to the sociology of prevention: 15 years' research on the social etiology of disease]. *Rev Epidemiol Sante Publique* 1987;35(1):3-19.
  61. Lilienfeld AM, Lilienfeld DE. Foundations of Epidemiology. Oxford: Oxford University Press, 1980.
  62. Sai Ft, Measham DM. Safe motherhood: getting our priorities straight. *Lancet* 1992;339:478-480.
  63. Sachs JD, McArthur JW. The Millennium Project: a plan for meeting the Millennium Development Goals. *Lancet* 2005;365(9456):347-53.
  64. Freedman LP, Waldman RJ, de Pinho H, Wirth ME, Chowdhury AM, Rosenfield A. Transforming health systems to improve the lives of women and children. *Lancet* 2005;365(9463):997-1000.
  65. Font F, Alonso Gonzalez M, Nathan R, et al. Maternal mortality in a rural district of southeastern Tanzania: an application of the sisterhood method. *Int J Epidemiol* 2000;29(1):107-12.
  66. Garenne M, Mbaye K, Bah MD, Correa P. Risk factors for maternal mortality: a case-control study in Dakar hospitals (Senegal). *Afr J Reprod Health* 1997;1(1):14-24.
  67. Moodley J. Saving mothers: 1999-2001. *S Afr Med J* 2003;93(5):364-6.
  68. Jafarey SN. Maternal mortality in Pakistan--compilation of available data. *J Pak Med Assoc* 2002;52(12):539-44.
  69. What is needed to ensure the health and survival of mother and baby? *Safe Mother* 1992(9):4-5.
  70. Granja AC, Machungo F, Gomes A, Bergstrom S. Adolescent maternal mortality in Mozambique. *J Adolesc Health* 2001;28(4):303-6.
  71. Ayhan A, Bilgin F, Tuncer ZS, Tuncer R, Yanik A, Kisinisci HA. Trends in maternal mortality at a university hospital in Turkey. *Int J Gynaecol Obstet* 1994;44(3):223-8.
  72. Maharaj D. Puerperal pyrexia: a review. Part I. *Obstet Gynecol Surv* 2007;62(6):393-9.
  73. Breslow L. Musings on sixty years in public health. *Annu Rev Public Health* 1998;19:1-15.
  74. Breslow L. Social ecological strategies for promoting healthy lifestyles. *Am J Health Promot* 1996;10:253-257.
  75. Comino EJ, Harris E. Maternal and Infant Services: examination of access in a culturally diverse community. *J Paediatr Child Health* 2003;39(2):95-9.
  76. Yen IH, Syme SL. The social environment and health: a discussion of the epidemiologic literature. *Annu Rev Public Health* 1999;20:287-308.
  77. Sword W. A socio-ecological approach to understanding barriers to prenatal care for women of low income. *J Adv Nurs* 1999;29(5):1170-7.
  78. Wingood GM, DiClemente RJ. HIV sexual risk reduction interventions for women: a review. *Am J Prev Med* 1996;12(3):209-17.
  79. Interventions to prevent HIV risk behaviors. National Institutes of Health Consensus Development Conference Statement February 11-13, 1997. *Aids* 2000;14 Suppl 2:S85-96.
  80. Sheppard BH, Hartwick J, Warshaw PR. The theory of reasoned action: a meta-analysis of past research with recommendations for modifications for future research. *J Cons Res* 1988;15:325-343.
  81. Berkman LF, Blumenthal J, Burg M, et al. Effects of treating depression and low perceived social support on clinical events after myocardial infarction: the Enhancing Recovery in Coronary Heart Disease Patients (ENRICHD) Randomized Trial. *JAMA* 2003;289(23):3106-16.
  82. DiClemente RJ, Wingood GM. A randomized controlled trial of an HIV sexual risk-reduction intervention for young African-American women. *JAMA* 1995;274(16):1271-6.
  83. Pellmar TC, Brandt EN, Jr., Baird MA. Health and behavior: the interplay of biological, behavioral, and social influences: summary of an Institute of Medicine report. *Am J Health Promot* 2002;16(4):206-19.
  84. Krummel DA, Koffman DM, Bronner Y, et al. Cardiovascular health interventions in women: What works? *J Womens Health Gen Based Med* 2001;10(2):117-36.
  85. Brown SM, Lubimova AV, Khrustalyeva NM, et al. Use of an alcohol-based hand rub and quality improvement interventions to improve hand hygiene in a Russian neonatal intensive care unit. *Infect Control Hosp Epidemiol* 2003;24(3):172-9.
  86. Rosenthal VD, McCormick RD, Guzman S, Villamayor C, Orellano PW. Effect of education and performance feedback on handwashing: the benefit of administrative support in Argentinean hospitals. *Am J Infect Control* 2003;31(2):85-92.
  87. Kilbride HW, Wirtschafter DD, Powers RJ, Sheehan MB. Implementation of evidence-based potentially better practices to decrease nosocomial infections. *Pediatrics* 2003;111(4 Pt 2):e519-33.
  88. Rotter ML. Semmelweis' sesquicentennial: a little-noted anniversary of handwashing. *Curr Opin Infect Dis* 1998;11(4):457-60.
  89. Rotter ML. Arguments for alcoholic hand disinfection. *J Hosp Infect* 2001;48 Suppl A:S4-8.

90. Cohen B, Saiman L, Cimiotti J, Larson E. Factors associated with hand hygiene practices in two neonatal intensive care units. *Pediatr Infect Dis J* 2003;22(6):494-9.
91. Lipsett PA, Swoboda SM. Handwashing compliance depends on professional status. *Surg Infect (Larchmt)* 2001;2(3):241-5.
92. Seto WH, Tsang D, Yung RW, et al. Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS). *Lancet* 2003;361(9368):1519-20.
93. Thomson O'Brien MA, Oxman AD, Davis DA, Haynes RB, Freemantle N, Harvey EL. Audit and feedback: effects on professional practice and health care outcomes. *Cochrane Database Syst Rev* 2000(2):CD000259.
94. Oxman AD, Thomson MA, Davis DA, Haynes RB. No magic bullets: a systematic review of 102 trials of interventions to improve professional practice. *Cmaj* 1995;153(10):1423-31.
95. Thomson O'Brien MA, Oxman AD, Haynes RB, Davis DA, Freemantle N, Harvey EL. Local opinion leaders: effects on professional practice and health care outcomes. *Cochrane Database Syst Rev* 2000(2):CD000125.
96. Davis DA, Thomson MA, Oxman AD, Haynes RB. Changing physician performance. A systematic review of the effect of continuing medical education strategies. *JAMA* 1995;274(9):700-5.
97. Davis DA, Thomson MA, Oxman AD, Haynes RB. Evidence for the effectiveness of CME. A review of 50 randomized controlled trials. *JAMA* 1992;268(9):1111-7.
98. Bero LA, Grilli R, Grimshaw JM, Harvey E, Oxman AD, Thomson MA. Closing the gap between research and practice: an overview of systematic reviews of interventions to promote the implementation of research findings. The Cochrane Effective Practice and Organization of Care Review Group. *BMJ* 1998;317(7156):465-8.
99. Trick WE, Vernon MO, Hayes RA, et al. Impact of ring wearing on hand contamination and comparison of hand hygiene agents in a hospital. *Clin Infect Dis* 2003;36(11):1383-90.
100. Rotter M. [Procedures for hand hygiene in German-speaking countries]. *Zentralbl Hyg Umweltmed* 1996;199(2-4):334-49.
101. Rotter ML, Koller W. Test models for hygienic handrub and hygienic handwash: the effects of two different contamination and sampling techniques. *J Hosp Infect* 1992;20(3):163-71.
102. Taha TE, Biggar RJ, Broadhead RL, et al. Effect of cleansing the birth canal with antiseptic solution on maternal and newborn morbidity and mortality in Malawi: clinical trial. *BMJ* 1997;315(7102):216-9; discussion 220.
103. Maharaj D. Puerperal Pyrexia: a review. Part II. *Obstet Gynecol Surv* 2007;62(6):400-6.
104. Wadsworth Y. What is participatory action research?: Action Research International, 1998.
105. Israel BA, Checkoway B, Schulz A, Zimmerman M. Health education and community empowerment: conceptualizing and measuring perceptions of individual, organizational, and community control. *Health Educ Q* 1994;21(2):149-70.
106. Schulz AJ, Parker EA, Israel BA, Allen A, Decarlo M, Lockett M. Addressing social determinants of health through community-based participatory research: the East Side Village Health Worker Partnership. *Health Educ Behav* 2002;29(3):326-41.
107. Freire P. Pedagogy of the oppressed. New York: Continuum Publication Co., 1970.
108. Hammond JL. Fighting to learn: popular education and guerrilla war in El Salvador. New Brunswick, NJ: Rutgers University Press, 1998.
109. Lewin J. Action research and minority problems. *J Social Issues* 1946;2(4):34-36.
110. McFarlane J, Fehir J. De Madres a Madres: a community, primary health care program based on empowerment. *Health Educ Q* 1994;21(3):381-94.
111. McKnight JL. Community health in a Chicago slum. *Development Dialogue* 1978;1:62-68.
112. Minkler M, Cox K. Creating critical consciousness in health: Applications of Freire's philosophy and methods to health care settings. *Int J Health Services* 1980;10(2):311-322.
113. Morse JM. Designing funded qualitative research. In: Denzin NK, Lincoln YS, eds. *Handbook of Qualitative Research*. Thousand Oaks, CA: Sage, 1994: 220-235.
114. Wallerstein N, Sanchez-Merki V. Freirian praxis in health education: research results from an adolescent prevention program. *Health Educ Res* 1994;9(1):105-18.
115. Fonn S, Xaba M. Health workers for change: developing the initiative. *Health Policy Planning* 2001;16:13-18.
116. Katarwa MN, Habomugisha P, Agunyo S. Involvement and performance of women in community-directed treatment with ivermectin for onchocerciasis control in Rukungiri District, Uganda. *Health Soc Care Community* 2002;10(5):382-93.
117. Manderson L, Mark T. Empowering women: participatory approaches in women's health and development projects. *Health Care Women Int* 1997;18(1):17-30.
118. Yach D. The use and value of qualitative methods in health research in developing countries. *Soc Sci Med* 1992;35(4):603-12.
119. Thomas JC, Earp JA, Eng E. Evaluation and lessons learned from a lay health advisor programme to prevent sexually transmitted diseases. *Int J STD AIDS* 2000;11(12):812-8.

120. Earp JA, Altpeter M, Mayne L, Viadro CI, O'Malley MS. The North Carolina Breast Cancer Screening Program: foundations and design of a model for reaching older, minority, rural women. *Breast Cancer Res Treat* 1995;35(1):7-22.
121. Eng E. The Save our Sisters Project. A social network strategy for reaching rural black women. *Cancer* 1993;72(3 Suppl):1071-7.
122. Altpeter M, Earp JA, Schopler JH. Promoting breast cancer screening in rural, African American communities: the "science and art" of community health promotion. *Health Soc Work* 1998;23(2):104-15.
123. McQuiston C, Flaskerud JH. "If they don't ask about condoms, I just tell them": a descriptive case study of Latino lay health advisers' helping activities. *Health Educ Behav* 2003;30(1):79-96.
124. Goodburn EA, Hussein J, Lema V, Damisoni H, Graham W. Monitoring obstetric services: putting the UN guidelines into practice in Malawi. I: developing the system. *Int J Gynaecol Obstet* 2001;74(2):105-17; discussion 118.
125. Iyun F. An assessment of a rural health programme on child and maternal care: the Ogbomoso Community Health Care Programme (CHCP), Oyo State, Nigeria. *Soc Sci Med* 1989;29(8):933-8.
126. Kande HB, Leigh B, Kanu MS, Kuteh M, Bangura J, Seisay AL. Community motivators promote use of emergency obstetric services in rural Sierra Leone. The Freetown/Makeni PMM Team. *Int J Gynaecol Obstet* 1997;59 Suppl 2:S209-18.
127. Kilonzo A, Kouletio M, Whitehead SJ, Curtis KM, McCarthy BJ. Improving surveillance for maternal and perinatal health in 2 districts of rural Tanzania. *Am J Public Health* 2001;91(10):1636-40.
128. Olsen BE, Hinderaker SG, Lie RT, Bergsjø P, Gasheka P, Kvale G. Maternal mortality in northern rural Tanzania: assessing the completeness of various information sources. *Acta Obstet Gynecol Scand* 2002;81(4):301-7.
129. Schmidt DH, Rifkin SB. Measuring participation: its use as a managerial tool for district health planners based on a case study in Tanzania. *Int J Health Plann Manage* 1996;11(4):345-58.
130. Flynn BC, Ray DW, Rider MS. Empowering communities: action research through healthy cities. *Health Educ Q* 1994;21(3):395-405.
131. Higgins DL, Maciak B, Metzler M. CDC Urban Research Centers: community-based participatory research to improve the health of urban communities. *J Womens Health Gen Based Med* 2001;10(1):9-15.
132. Howell EM, Devaney B, McCormick M, Raykovich KT. Back to the future: community involvement in the Healthy Start Program. *J Health Polit Policy Law* 1998;23(2):291-317.
133. Lydon-Rochelle M, West M, Hayes M, Taylor P. Midwives and maternal and child health: building resource capacity. *J Midwifery Womens Health* 2001;46(2):103-8.
134. Minkler M. Using Participatory Action Research to build Healthy Communities. *Public Health Rep* 2000;115(2-3):191-7.
135. Nelson G, Prilleltensky I, MacGillivray H. Building value-based partnerships: toward solidarity with oppressed groups. *Am J Community Psychol* 2001;29(5):649-77.
136. Pistella CY, Synkewecz CA. Community postpartum care needs assessment and systems development for low income families. *J Health Soc Policy* 1999;11(1):53-64.
137. Berer M, Ravindran T, S. Safe Motherhood Initiatives: critical issues. London: Blackwell Science, 1999.
138. AbouZahr CL. Lessons on safe motherhood. *World Health Forum* 1998;19(3):253-60.
139. Thompson A. Poor and pregnant in Africa: safe motherhood and human rights. *Midwifery* 1999;15(3):146-53.
140. Fawcus S, Mbizvo M, Lindmark G, Nystrom L. A community-based investigation of avoidable factors for maternal mortality in Zimbabwe. *Stud Fam Plann* 1996;27(6):319-27.
141. Fikree FF, Midhet F, Sadruddin S, Berendes HW. Maternal mortality in different Pakistani sites: ratios, clinical causes and determinants. *Acta Obstet Gynecol Scand* 1997;76(7):637-45.
142. AbouZahr C. Safe motherhood: a brief history of the global movement 1947-2002. *Br Med Bull* 2003;67:13-25.
143. World Health Organization. The World Health Report 2005: Make every mother and child count. Geneva: WHO, 2005.
144. MANA. Safe Motherhood Quilt Project: Midwives Alliance of North American, 2004.
145. Jones WK. Safe motherhood: promoting health for women before, during, and after pregnancy. Atlanta: National Center for Chronic Disease Prevention and Health Promotion, 2004.
146. Hunt J. Trying to make a difference: improving pregnancy outcomes, care and services for Australian Indigenous women: La Trobe University, 2003.
147. Fathalla MF. The Hubert de Watteville Memorial Lecture. Imagine a world where motherhood is safe for all women--you can help make it happen. *Int J Gynaecol Obstet* 2001;72(3):207-13.
148. Schmid T, Kanenda O, Ahluwalia I, Kouletio M. Transportation for maternal emergencies in Tanzania: empowering communities through participatory problem solving. *Am J Public Health* 2001;91(10):1589-90.
149. Ahluwalia IB, Schmid T, Kouletio M, Kanenda O. An evaluation of a community-based

- approach to safe motherhood in northwestern Tanzania. *Int J Gynaecol Obstet* 2003;82(2):231-40.
150. Lazenbatt A, Lynch U, O'Neill E. Revealing the hidden "troubles" in Northern Ireland": the role of participatory rapid appraisal. *Health Educ Research* 2001;16(5):567-578.
  151. Bradley JE, Mayfield MV, Mehta MP, Rukonge A. Participatory evaluation of reproductive health care quality in developing countries. *Soc Sci Med* 2002;55(2):269-82.
  152. Jenicek M, Stachenko S. Evidence-based public health, community medicine, preventive care. *Med Sci Monit* 2003;9(2):SR1-7.
  153. Jenicek M. Epidemiology, evidence-based medicine, and evidence-based public health. *J Epidemiol* 1997;7:187-197.
  154. Aveyard P. Evidence-based medicine and public health. *J Eval Clin Pract* 1997;3(2):139-44.
  155. Glasziou P, Longbottom H. Evidence-based public health practice. *Aust N Z J Public Health* 1999;23(4):436-40.
  156. Brownson RC, Gurney JG, Land GH. Evidence-based decision making in public health. *J Public Health Manag Pract* 1999;5(5):86-97.
  157. Eriksson C. Learning and knowledge-production for public health: a review of approaches to evidence-based public health. *Scand J Public Health* 2000;28(4):298-308.
  158. Frumkin H. Healthy places: exploring the evidence. *Am J Public Health* 2003;93(9):1451-6.
  159. Sackett DL, Haynes RB, Tugwell P. *Clinical Epidemiology: A Basic Science for Clinical Medicine*. Boston: Little Brown, 1985.
  160. Ronenberg W, Donald A. Evidence-based medicine: an approach to clinical problem-solving. *BMJ* 1995;310:1122-1126.
  161. Sackett DL, Rosenberg WMC, Muir Gray JA, et al. Evidence-based medicine: what it is and what it isn't. *BMJ* 1996;312(71-72).
  162. Sackett DL, Straus S, Richardson SR, Rosenberg W, Haynes RB. *Evidence-based medicine: how to practice and teach EBM*. London: Churchill Livingstone, 2000.
  163. Foy R, Crilly M, Brechin S. Evidence-based reproductive health: testing times for treatments. *J Fam Plann Reprod Health Care* 2003;29(3):165-8.
  164. Humphries KH, Gill S. Risks and benefits of hormone replacement therapy: the evidence speaks. *Cmaj* 2003;168(8):1001-10.
  165. Hunt JM, Lumley J. Are recommendations about routine antenatal care in Australia consistent and evidence-based? *Med J Aust* 2002;176(6):255-9.
  166. Lumley J, Austin MP. What interventions may reduce postpartum depression. *Curr Opin Obstet Gynecol* 2001;13(6):605-11.
  167. Stein ZA. Silicone breast implants: epidemiological evidence of sequelae. *Am J Public Health* 1999;89(4):484-7.
  168. Jadad AR, Haynes RB. The Cochrane Collaboration - advances and challenges in improving evidence-based decision-making. *Med Decision Making* 1998;18:2-9.
  169. Cwikel J. A comparison of a vote count and a meta-analysis review of intervention research with adult cancer patients. *Res Social Work Pract* 2000;10(1):139-158.
  170. Britton A, McKee M, Black N, McPherson K, Sanderson C, Bain C. Choosing between randomised and non-randomised studies: a systematic review - Executive Summary. *Health Tech Assessment* 1998;2(13):1-4.
  171. Haynes RB. What kind of evidence is it that Evidence-Based Medicine advocates want health care providers and consumers to pay attention to? *BMC Health Serv Res* 2002;2(1):3.
  172. Morris CD, Carson S. Routine vitamin supplementation to prevent cardiovascular disease: a summary of the evidence for the U.S. Preventive Services Task Force. *Ann Intern Med* 2003;139(1):56-70.
  173. Concato J, Shah N, Horwitz RI. Randomized, controlled trials, observational studies, and the hierarchy of research designs. *N Engl J Med* 2000;342(25):1887-92.
  174. Benson K, Hartz AJ. A comparison of observational studies and randomized, controlled trials. *N Engl J Med* 2000;342(25):1878-86.
  175. Haynes RB, Devereaux PJ, Guyatt GH. Physicians' and patients' choices in evidence based practice. *BMJ* 2002;324(7350):1350.
  176. Milne L, Scotland G, Tagiyeva-Milne N, Hussein J. Safe motherhood program evaluation: theory and practice. *Journal of Midwifery & Women's Health* 2004;49(4):338-344.
  177. Munjanja SP, Lindmark G, Nystrom L. Randomised controlled trial of a reduced-visits programme of antenatal care in Harare, Zimbabwe. *Lancet* 1996;348(9024):364-9.
  178. Carroli G, Villar J, Piaggio G, et al. WHO systematic review of randomised controlled trials of routine antenatal care. *Lancet* 2001;357(9268):1565-70.
  179. Villar J, Ba'aqeel H, Piaggio G, et al. WHO antenatal care randomised trial for the evaluation of a new model of routine antenatal care. *Lancet* 2001;357(9268):1551-64.
  180. World Health Organization. *Skilled attendant at birth - 2007 updates*, 2007.
  181. Knippenberg R, Lawn JE, Darmstadt GL, et al. Systematic scaling up of neonatal care in countries. *Lancet* 2005;365(9464):1087-98.
  182. Ronsmans C, Endang A, Gunawan S, et al. Evaluation of a comprehensive home-based midwifery programme in South Kalimantan,

- Indonesia. *Trop Med Int Health* 2001;6(10):799-810.
183. Fauveau V, Stewart K, Khan SA, Chakraborty J. Effect on mortality of community-based maternity-care programme in rural Bangladesh. *Lancet* 1991;338(8776):1183-6.
184. Ronsmans C, Vanneste AM, Chakraborty J, van Ginneken J. Decline in maternal mortality in Matlab, Bangladesh: a cautionary tale. *Lancet* 1997;350(9094):1810-4.
185. Majoko F, Nystrom L, Munjanja S, Lindmark G. Usefulness of risk scoring at booking for antenatal care in predicting adverse pregnancy outcome in a rural African setting. *J Obstet Gynaecol* 2002;22(6):604-9.
186. Kapronszay K. Semmelweis. Budapest, Hungary: Semmelweis Museum, Library and Archives of Medical History, 2004: 1-36.
187. Glasier A, Gulmezoglu AM, Schmid GP, Moreno CG, Van Look PF. Sexual and reproductive health: a matter of life and death. *Lancet* 2006;368(9547):1595-607.
188. Koblinsky MA, Tinker A, Daly P. Programming for safe motherhood: a guide to action. *Health Policy Plan* 1994;9(3):252-66.
189. Fathalla MF. Human rights aspects of safe motherhood. *Best Pract Res Clin Obstet Gynaecol* 2006;20(3):409-19.

