

patients are m_0 , m_1 and m_2 , where $m_0 < m_1 < m_2$. With this model, it is not difficult to show that prioritizing high-risk cases leads to fewer cardiac deaths and greater overall survival. The number of deaths on the waiting list in steady state is still independent of queuing strategy, but if high-risk cases are prioritized, then a greater proportion of waiting-list deaths are of noncardiac origin.

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DOI:10.1503/cmaj.1040290

[The author responds:]

In this letter, I comment on both the commentary by David Naylor and associates,¹ published in conjunction with my own commentary² and on the subsequent letter from John Neary.

I have had difficulty responding to the “critique” by Naylor and associates¹ because it is clouded in rhetoric. To help readers decide if my analysis was “flawed,” I would like to take this opportunity to spell it out in more detail.

The model I used was a deterministic version of the immigration–death process, a continuous-time, discrete-space Markov process.³ With reasonably large numbers, the result for the deterministic model is the same as the mean of the stochastic model. In the context of the waiting list problem, let $N(t)$ be the instantaneous rate of admission to the list (expressed as patients per year), $S(t)$ the rate of surgery and m the mortality rate of patients on the waiting list (deaths per patient-year). Suppose that before time zero, $S(t) = N(t)$, such that no patients are waiting, but that at time zero, $S(t)$ falls below $N(t)$ and the difference remains constant at, say,

$N - S = D$. Then the differential equation for $Q(t)$, the size of the waiting list at time t , is $dQ/dt = D - mQ(t)$. The solution is $Q(t) = [1 - \exp(-mt)]D/m$. Thus, as t increases, $Q(t)$ approaches exponentially the steady-state value $Q = D/m$, and the number of deaths per year in the steady state is $mQ = D$ (constant). If we compare the steady states reached with different values of m , we find that the size of the waiting list will vary inversely with m , but the number of deaths per year will remain the same. For example, if m is reduced by operating preferentially on patients with a greater risk of dying, then *in the steady state* the size of the waiting list is increased but the number of deaths per year is unaltered (emphasis has been added here because Neary counts deaths en route to the steady state and gets a different result). In my commentary, I used the example of 2 risk groups, but the analysis can be extended to any number of groups, and to the situation of progression between groups, with the same conclusion.

The same model underlies the formula used in epidemiology: prevalence = incidence \times duration. If the disease is incurable but palliative treatment reduces the mortality rate of those with the disease, then the prevalence of the disease increases but the number of deaths per year remains the same.

Both Naylor and associates¹ and Neary state that my argument is tautological, and I agree. All mathematical models are tautologies, but they sometimes produce results that are not intuitively obvious and that can be especially useful if the conclusions can be tested empirically. This is true in principle in this case, but the data may be difficult to obtain.

Neary’s suggestion that cardiac deaths be distinguished from deaths due to other causes adds an interesting dimension to the analysis. If priority is given to patients with increased cardiac risk, then the proportion of cardiac deaths will be reduced, even though the total number of deaths per year is unchanged. In effect, deaths from other causes are substituted for cardiac deaths. The proportion of

noncardiac deaths is thus a measure of the effectiveness of the selection process. (For more mathematical detail, see the online appendix to this letter at www.cmaj.ca.) Plomp and colleagues⁴ have published a breakdown of deaths by cause on Dutch waiting lists, and it would be interesting to compare their results with data from other jurisdictions.

Recently the federal and provincial governments have committed themselves to getting rid of waiting lists. If they attempt to do so by making $S(t) = N(t)$, then the waiting list will remain until patient deaths reduce it to zero. If it took 15 years for the waiting list to develop, then it will take 15 years to eliminate it. To avoid the delay, an oversupply of resources will be needed.

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DOI:10.1503/cmaj.1040379

Clarification

CMAJ wishes to clarify statements made in an editorial “What’s wrong with CME?” published on March 16, 2004. Contrary to what was published, mdBriefCase and sponsoring pharmaceutical companies agree on the clinical area to be covered by the case study but do not choose the specific CME topic, design the course content or select the course leaders.

John Hoey

Editor
CMAJ

DOI:10.1503/cmaj.1040916