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RISK OF SUICIDE IN JUVENILE JUSTICE FACILITIES

The Problem of Rate Calculations in High-Turnover Populations

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Two recent publications have reported vastly different rates of suicide in juvenile-justice residential facilities using the same data. Similarly, divergent rates were calculated on juvenile suicides while in custody using the same data in the 1980s. Using data from the Juvenile Residential Facility Census and the Census of Juveniles in Residential Placement, this article demonstrates the underlying differences in the suicide rate calculations by drawing on the historical and epidemiological literature. It highlights the arithmetical relationships between the rates and suggests which methods are best depending on the purpose of the exercise. Facility administrators may find beds-based rates more meaningful for comparisons on rates of suicide across facilities, whereas mental health professionals may prefer person-based rates to describe the risk of suicide in the juvenile justice population.

Keywords: juvenile corrections; suicide; rate calculation; JRFC; CJRP

The literature on youth in custody suggests that these juveniles are uniquely vulnerable to suicide and suicidal behavior (Hayes, 2004b; Parent et al., 1994). Recognizing the potential for a heightened risk, the nearly 3,700 juvenile-justice residential facilities in the United States housing an average of 105,000 young people (Sickmund, 2002) have been encouraged to undertake prevention methods, such as screening, staff training (Gallagher & Dobrin, 2005; Hayes, 2004a), and incorporating safety into the design of physical structures (National Commission on Correctional Health Care [NCCHC], 2004). Given the amount of resources and concern dedicated to preventing suicidal behavior, it is reasonable to first determine how the facility rate compares to the general population of adolescents.

Establishing acceptable benchmarks for comparisons between the facility and general populations of adolescents is difficult.[1] One standard may be that the suicide rate should be no worse in facilities than on the outside. This recognizes both the dampening effect of prevention, surveillance, and restrictions as well as the counter-effects of the high-risk nature

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of youth in custody. It also acknowledges that the time surrounding arrest, adjudication, and confinement is typically one of a psychosocial crisis (American Academy of Child and Adolescent Psychiatry, 2001).

Several studies have undertaken the comparison of facility and general population rates (Flaherty, 1980; Gallagher & Dobrin, 2006a; Memory, 1989; Snyder, 2005), producing substantially different results. The Flaherty (1980) and Memory (1989) studies used the same data, as did the Gallagher and Dobrin (2006a) and Snyder (2005) studies. Flaherty (1980) estimated a facility rate[2] of 1.6 and Memory (1989), a rate of 57.0. Gallagher and Dobrin (2006a) calculated the facility rate at 23.35, although Snyder (2005) concluded that it was about 10. If the suicide rate in the general population falls somewhere between 7 and 9 (Arias, Anderson, Kung, Murphy, & Kochanek, 2003), the highly variable rates produced from these studies provide no guidance to policy makers and practitioners concerned with allocating resources toward curbing suicidal behavior. On one hand, it appears that the rate is substantially lower or equal to the general population (Flaherty, 1980; Snyder, 2005); on the other hand, it appears that more needs to be done to reduce a seriously inflated rate (Gallagher & Dobrin, 2006a; Memory, 1989).

On the face of it, the differences in the rate calculations across these studies should be a matter of simple arithmetic. However, as history reveals (Nightingale, 1863), such divergence is no simple matter and has been the subject of some of the more contentious debates in the health policy field (Iezzoni, 1996a; see also Gerstman, 2003). For example, in calculating hospital death rates—a critical measure of hospital performance—differences in assumptions and methods can produce substantially different death rates. Because hospitals have unique characteristics in terms of the populations they serve and the amount of time that patients are under their care, the calculations are not as obvious as death rates for the general population. These debates have direct relevance for the accurate calculation of death rates in high-turnover correctional populations such as those found in juvenile justice facilities and jails.

This article seeks to make sense of the disparate rate calculations so that policy implications may be clarified. This is done by applying the debates surrounding hospital-death-rate calculations to the problem of suicide-rate calculations in juvenile justice facilities and other institutions with lengths of stay that average fewer than 365 days per year. The article begins with a historical overview of the debate, which appears to have originated in London in the mid-1800s. It then turns to the contemporary problem at hand: how four studies could produce dramatically different rates and how a suicide rate in the juvenile residential facility population may be computed so that it is directly comparable to the risks faced by young people in the general population. The impact of differences in rates between the general and facility population will be discussed in the context of facility policies and practices.

THE CASE OF 100 APPLES DIVIDED BY 15 RED HERRINGS

In an effort to hold hospitals in and around London publicly accountable, Florence Nightingale (1863) published mortality rates in her volume *Notes on Hospitals*. Using data selected from the work of William Farr, a prominent epidemiologist of the time, she noted that London hospitals had mortality rates greater than 90%. This rate was achieved by dividing the total number of deaths in a year in London hospitals by the number of patients on a given day, providing the death rate per average number of occupied beds (Nightingale, 1863).

A public debate ensued (Farr, 1864a, 1864b; Holmes, 1864). Medical professionals attacked Nightingale's and Farr's calculations, noting that the death rate dropped to 10% if the denominator was the total number of admissions for the 1-year period (rather than the number of patients on a single day), providing a rate of death per total admissions (Holmes, 1864). The central problem between the two calculations is how to account for the critical element of observation time: that is, the number of days patients remain in hospitals or the amount of time there is an opportunity to observe a death.

> Farr wanted to hold constant the window of observation, saying, for example, that it was unfair to compare death rates at St. Thomas's in London (average inpatient stay, 39 days) with rates at two Dublin hospitals (average stay, 27 days). At least, Farr argued, his calculation was clear in exactly what it was observing. (Iezzoni, 1996a, p. 1081)

Time has not settled the debate. In a terse exchange in the *Annals of Internal Medicine*, Iezzoni (1996a, 1996b, 1996c) and Vandenbroucke and Vandenbroucke-Grauls (1996, 1997) carried on where Farr and his critics left off. Noting that length-of-stay data were unavailable at the time, Iezzoni explained that at least the beds-based figure provided some method of standardization (i.e., beds) across hospitals. Vandenbroucke and Vandenbroucke-Grauls countered in Farr's defense, appearing (but not clearly articulating) to suggest that the Farr method does in fact account for length of stay. The link, however, is less than obvious and appears to occur through the issue of total patient-day rates (Vandenbroucke & Vandenbroucke-Grauls, 1996). Iezzoni (1996c) countered that such patient-day rates are more difficult to understand than admissions-based rates: "Given the common English meaning of the words 'death rate,' such figures would not make intuitive sense to the average reader" (p. 171). Vandenbroucke and his colleague (1996) retorted that this should not deter epidemiologists from correct calculations.

The rate-calculations debates are more than intellectual banter. Epidemiology as a field has begun standardizing basic conceptual definitions only in recent decades (Elandt-Johnson, 1975; Rothman & Greenland, 1998a; Vandenbroucke, 2003). Individual hospitals and units within hospitals serve diverse purposes and populations, making fair comparisons of death rates difficult. Because mortality rates represent a critical measure of hospital quality (see, e.g., the publications made public on hospital mortality rates, such as the 2005 report on hospital-acquired infections in Pennsylvania by the Pennsylvania Health Care Cost Containment Council), it is all the more important that rate calculations are comparable across units. Nonetheless, as Iezzoni (1996a) noted, "The statistical methods used in these high-profile performance reports for comparing hospital mortality rates have frequently generated esoteric debates among methodologists, but even such basic issues as specifying numerators and denominators remain controversial" (p. 1083).

Placed in the context of the historical debates and the differing methods of calculations, it is no wonder that disparate rates have been calculated on suicide in the juvenile-justice residential facility population using the same data. The following discussion examines the two sets of studies in terms of the methods used to calculate suicide rates.

THE FLAHERTY AND MEMORY STUDIES

Both of these studies used data collected as part of a report of the Community Research Center (CRC) of the University of Illinois (Flaherty, 1980; Memory, 1989). The data were collected in the 1970s by gathering information on juvenile suicides in adult facilities and

TABLE 1: The Differing Rate-Calculation Methods Used to Estimate Suicide Rates in Juvenile Residential Facilities

Calculation Source	*Formulae*	*Calculations and Rates*
Flaherty	(Number of suicides in detention centers in 1978 ÷ number of juveniles admitted to detention centers in 1978) × 100,000 (unit unspecified, but inferred as total admissions)	(6 ÷ 383,238) × 100,000 = 1.6 per 100,000 admissions per year
Memory	(Number of suicides in detention centers in 1978 ÷ average daily population) × 100,000 population in detention centers in a year	(6 ÷ 10,499.67[a]) × 100,000 = 57 per 100,000 average daily population per year
Snyder	(Suicides in juvenile residential facilities in 2000 ÷ average daily population) × 100,000 average daily population per year	Inferred as (10 ÷ 106,336) × 100,000 = 9.4 per 100,000 average daily population
Gallagher and Dobrin	(Average number of suicides in juvenile residential facilities in 2000 and 2002 ÷ [average number of days of risk exposure × average daily population]) × 100,000 young-person-risk days per year × 365 days of risk observation	(10 ÷ [147 × 106,336]) × 100,000 = 0.06 per 100,000 young people per confinement day 0.06 × 365 = 23.35 per 100,000 young people per confinement year
	Equivalent to (Average number of suicides in juvenile residential facilities in 2000 and 2002 ÷ average number of days of risk exposure ([i.e., length of stay] per average daily population per year) × 365 days of risk observation	(10 ÷ 147) per 106,336 = 0.06 per 100,000 young people per confinement day 0.06 × 365 = 23.35 per 100,000 young people per confinement year

a. Calculation of average daily population size (383,238 × 10) ÷ 365 = Daily population of 10,499.67.

juvenile detention centers. The rates discussed in these two studies focus on the detention centers—those facilities holding young people who are typically awaiting adjudication or placement in other facilities. Detention centers tend to have shorter lengths of stay and more heterogeneity of offenders in terms of age, psychosocial background, and offense characteristics. It is widely thought that the risk of suicide is highest in these facilities, largely in part because of the findings in adult correctional population showing suicide to be most likely very early in the custody chain (Hayes, 2004b).

THE FLAHERTY (CRC) STUDY

All juvenile detention centers were asked to provide a total count of admissions during 1978 as well as a count of suicides occurring that year. Using these two pieces of data, Flaherty's (1980) calculation (see Table 1) resulted in a suicide rate of 1.6 per 100,000 (unit unspecified but taken to be admissions). This rate is analogous to the 10% mortality rate calculation in the Nightingale debate.

THE MEMORY STUDY

Memory's (1989) study was undertaken to correct what he saw as irregularities in the methods of Flaherty's (1980) calculations of the CRC data. Memory took issue with comparing suicide deaths per 100,000 admissions in detention centers with suicides per 100,000 young people in the general population, noting pointedly that

> these two types of annual suicide rates cannot be compared directly because each member of the general population might have committed suicide on any one of the 365 days during the year, while admittees to detention facilities might have committed suicide, for purpose of calculation of the rates, only during the indicated admissions. (Memory, 1989, p. 457)

The remainder of his study was devoted to recalculating the CRC figures. Memory took the total admissions figure and multiplied it by a length of stay estimated from a separate data source (the now defunct Census of Children in Custody, which was sponsored by the Office of Juvenile Justice and Delinquency Prevention [OJJDP]; see Table 1). He then divided by 365 to produce an estimate of the average daily population. He used the resulting figure as the denominator, concluding that the rate of suicide is 57 per 100,000 average daily-detention population (or average number of occupied beds)—considerably higher than Flaherty's rate for the juvenile detention population and the computed rate of 12.4 suicides per 100,000 in the general population of adolescents (see Table 1). Memory's rate is similar to that offered originally by Farr and Nightingale (90% mortality).

THE SNYDER AND GALLAGHER AND DOBRIN STUDIES

Both Snyder (2005) and Gallagher and Dobrin (2006a) used data from two OJJDP national censuses of all public and private juvenile justice facilities in the United States: the Juvenile Residential Facilities Census (JRFC) and the Census of Juveniles in Residential Placement (CJRP). The criteria for inclusion in these censuses is that the facilities must house young persons younger than the age of 21 who have been charged with or adjudicated for an offense and are housed in that facility because of that offense. Thus, both short-term detention and long-term placement are covered. The JRFC and CJRP are rotated so that one census is conducted every October. The CJRP was introduced in 1997 and the JRFC in 2000. Data from the JRFC 2004 collection are not yet available.

Data are gathered on deaths of young people in each administration of the JRFC. For example, the JRFC administered in 2002 asks all facility respondents, "During the *year* between October 1, 2001, and September 30, 2002, did *any* young persons die while assigned a bed at this facility?" (emphasis in original). Those responding yes are subsequently asked to provide a count of deaths and to indicate the cause of death, including suicide among the list of seven specific causes. Respondents are further instructed to indicate whether the death occurred on or off facility grounds.

The 2000 and 2002 JRFC do not contain any individual-level information about the young people who died; it simply collects a count by type of death. The JRFC captures a total population count of all young people assigned beds on the reference day (the fourth Wednesday of October), whereas the CJRP collects individual-level data on each young person assigned to a bed, including his or her age, sex, race, most serious offense, and status in the juvenile system.

THE SNYDER STUDY

Snyder's sole purpose was to assess whether the rate of suicide in juvenile facilities is higher or lower than the general population. He acknowledged the complexities involved in comparing death rates in facilities to those in the general population because the periods of observation are not equivalent. He handled this discrepancy by relying, as both Farr and Memory did, on an occupied-beds-based calculation (the formula was not shown but is inferred here). That is, he divided the number of suicides observed in a year by a population count on a single day (see Table 1). Snyder justified this approach by explaining that although the young people in the beds will change, their characteristics are stable. Thus, new occupants take the place of those who have been released.

THE GALLAGHER AND DOBRIN STUDY

In addition to examining facility-level factors associated with the risk of death and deaths from suicide, the Gallagher and Dobrin study (2006a) also sought to determine whether the facility death rates were comparable to the general population of young people. As Table 2 indicates, the numerator for these authors was an average of 2 years of JRFC suicide death counts, which amounts to an average of 10 suicides per the 365-day reference period (see column 2).

The authors provided several different denominators as they formulated their equation. First, like Snyder, Memory, and Farr, they divided the number of suicide deaths by the average population count reported on the reference day (see column 3 and footnote to Table 2) for an occupied-beds-based rate.

The authors noted that although this beds-based rate does standardize the comparison unit (beds), it does not provide the rate of risk for the people in the beds. In other words, the young people occupying the beds are only exposed to facility-based risks for 147 days, whereas the young people occupying beds in their homes in the general population are exposed to 365 days of population-based risks. Note, however, that in both cases, the beds themselves could be potentially observed for 365 days and that the turnover population is, in all likelihood, similar. To adjust the beds-based rate to account for time of risk exposure, the authors used the equation in Table 1.

The authors claim that the result of the calculation is a daily rate of death of .06 per 100,000 young people per confinement day per year (see Table 2, column 4) or a corresponding rate of death of 23.35 per 100,000 young people per confinement year (see Table 2, column 5). They further argue that this person-based rate is a more meaningful and equivalent rate for comparisons across populations because it describes the risk for young people, not beds.

TYPES OF SUICIDE-RATE CALCULATIONS

Like the debate following the Nightingale and Farr hospital-mortality calculations—and its contemporary found in Iezzoni and Vandenbroucke—little consensus has emerged on how to best calculate a suicide rate for the turnover population in juvenile justice facilities. As the review of the four studies above shows, different calculations resulted in widely disparate conclusions. This section dissects the relationships among the calculations.

There are essentially three types of rates calculated in these studies: a beds-based or average daily population rate, an admissions-based rate, and an adjusted person-based rate. For each, the numerator is simply the number of suicides during a 365-day observation period. The studies depart from one another in selecting denominators (see Table 3): Both

TABLE 2: Risk of Death of Young People in Juvenile Justice Confinement by Cause of Death, 2000 and 2002

	Total Deaths in Juvenile Justice (JJ) Confinement for 2000 and 2002	*Average Number of Deaths per Year*		*Risk of Death per 100,000 Young People per Year*[a,b]		*Risk of Death per 100,000 Young People per Day per Year*[c,d]		*Rate of Death per 100,000 Young People per Year*[e]	
		In JJ Confinement	National Population	In JJ Confinement	National Population	In JJ Confinement	National Population	In JJ Confinement	National Population
Total deaths	62	31	13,563	29.5	67.08	.20	.18	72.31	67.08
Suicide	20	10	1,611	9.40	7.90	.06	.02	23.35	7.90
Homicide by nonresident	6	3	1,899	2.82	9.37	.02	.03	7.30	9.37
Accident	17	8.5	6,646	7.99	32.79	.05	.09	18.25	32.79
Illness or natural causes	14	7		6.58		.04			
Other	5	2.5		2.35		.02		21.9	17.02

SOURCE: National Centers for Health Statistics, Centers for Disease Control and Prevention (2004); National Institute of Mental Health (2004).
Note. This table is adapted from Gallagher and Dobrin (2006a).
a. Risk of death in confinement per year calculated as (average number of deaths per year/average number of young people in confinement [106,336] × 100,000).
b. Comparable national risk per year: Risk of death in general population per year calculated as (number of deaths per year/number at risk in population aged 15-19 [20,219,890] × 100,000).
c. Comparable national risk per day: Risk of death in confinement per confinement day served calculated as (average number of deaths per year/number of young people × days in confinement [15,646,939] × 100,000).
d. Risk of death in general population per day calculated as (number of deaths per year/number at risk in population aged 15-19 × number of days at risk [20,219,890 × 365] × 100,000). Population figures are from the U.S. Census Bureau (2001).
e. The national yearly rates of death are calculated as (the daily rate × 365 days).

TABLE 3: Three Types of Rate Calculations in the Literature on Suicide in Residential Facility

	Beds Based		*Admissions Based*	*Person-Day Based*
Study	*Snyder*	*Memory*	*Flaherty (CRC)*	*Gallagher and Dobrin*
Denominator	Occupied beds (average daily population) on a single day	(Total admissions × average length of stay)/365 = average daily population	Total admissions per year	Average length of stay
Standardizing factors	100,000 occupied beds	100,000 average daily population	100,000 admissions	100,000 young people confined and 365 days
Data source	JRFC/CJRP	CRC survey and Children in Custody	CRC survey	JRFC/CJRP
Resulting rate	Unspecified but inferred as about 9.4	57	1.6	23.35

Note. CRC = Community Research Center of the University of Illinois; JRFC = Juvenile Residential Facilities Census; CJRP = Census of Juveniles in Residential Placement.

Snyder (2005) and Memory (1989) relied on average number of occupied beds (which should be considered synonymous with average daily population), the Flaherty (1980) study used total admissions during a 1-year period, and Gallagher and Dobrin (2006a) estimated a person-day denominator (to calculate a person-per-day rate) using the number of occupied beds and the average length of stay.

As is evident from Table 3, the denominator substantially impacts the rates. There are a few intuitive but not articulated arithmetic observations among these calculations. We illustrate three relationships and tie them back to the Nightingale debates. These observations provide two conclusions. First, despite different denominators, all of the rates are mathematically linked. Second, any differences in calculations should stem directly from assumptions about what constitutes a meaningful comparison (i.e., what theoretical question is being addressed).

Observation 1. Each set of rate calculations presented above is mathematically linked through the proportional volume of observation time (see Table 4). The relationship between the Snyder (2005) and the Gallagher and Dobrin (2006a) equations lies in the number 2.48—the proportional difference in observation time between the two studies.

Likewise the relationship between the Memory (1989) and Flaherty (1980) studies is 36.5. These observations mean that Memory could have multiplied Flaherty's rate (1.6) by the proportional difference (36.5) and produced the same rate (57.0) as his more involved calculations.

Farr's bed-based calculation (a 90% death rate) and the total admissions-based calculation of his critics (a 10% death rate) are also implicitly linked through the proportion of observation time, although this relationship is slightly more involved and requires incorporating Observation 2 below.

Observation 2a. Occupied-beds-based calculations (those with denominators of the average population size on a single day) latently distribute the risk of interest equally over 365 days. This is best demonstrated by recalculating the Snyder study using the preliminary methods of Gallagher and Dobrin (see Table 5). Note that adding 365 days to the denominator in the first steps of the calculation does not alter Snyder's resulting rate.

TABLE 4: The Relationship Between the Different Rate-Calculation Equations

Relationship	*Different Calculation Equations*
Between the Snyder and the Gallagher and Dobrin equations	365 days (Snyder volume of observation time) ÷ 147 days (Gallagher and Dobrin volume of observation time) = 2.48 23.3 suicides (Gallagher and Dobrin rate) ÷ 9.4 suicides (Snyder rate) = 2.48 0.064 suicides (Gallagher and Dobrin daily rate) ÷ 0.026 suicides (Snyder daily rate) = 2.48
Between the Flaherty and Memory equations	365 days (Flaherty volume of observation time) ÷ 10 days (Memory volume of observation time) = 36.5 57 suicides (Memory rate) ÷ 1.6 suicides (Flaherty rate) = 36.5

TABLE 5: Recalculating the Snyder Study Using the Methods of Gallagher and Dobrin

Original Snyder Method	*Snyder Study Recalculated Using Gallagher and Dobrin Method*
(10 ÷ 106,336) × 100,000 = 0.02 suicides per average daily population	10 ÷ 365 = 0.027 per 106,336 occupied beds 0.02 per day at risk per 100,000 average daily population (or occupied beds) 0.02 × 365 = 9.4 suicide deaths per 100,000 average daily population per year

TABLE 6: Total Person-Day and Average Daily Population Rates Are Mathematically Equivalent

Average Daily Population Rate	*Total Person-Day Rate Calculation*
(Suicides in juvenile residential facilities in 2000 ÷ average daily population) × 100,000 average daily population per year	(Number of suicides in juvenile residential facilities in 2000 ÷ total number of person days served) × 100,000 young-person-risk days per year
(10 ÷ 106,336) × 100,000 = 9.4 per 100,000 average daily population	(10 ÷ 263,713[a]) × 100,000 = 9.4 suicides per 100,000 total person days served

a. Total admission calculated as 365 ÷ 147 (average length of stay) = 2.48; 106,336 × 2.48 = 263,713.

Observation 2b. Occupied-beds-based calculations (i.e., calculations based on the average day's population) should be mathematically equivalent to yet another type of rate calculation, the rate of death per total patient days (i.e., calculations based on the total number of admissions and the average number of days in a facility). This is the precisely the point that Vandenbroucke and Vandenbroucke-Grauls were trying to illustrate: That a beds-based rate calculated using a denominator of the population count on a single day theoretically is exactly the same as a total patient-day rate. This is illustrated in Table 6.

After a careful reading, Vandenbroucke and Vandenbroucke-Grauls appear to have argued that Iezonni missed the value in the beds-based rate provided by Farr and adopted by Nightingale. This is because Iezonni failed to recognize that a beds-based rate inherently includes an adjustment for length of stay.

Observation 2c. The denominator of bed-based rates (and therefore total patient-day rates) inherently adjusts for length of stay. This is not the same as the person-day rate also presented by Gallagher and Dobrin (2006a). They first adjust for length of stay (as Snyder, Farr, and Memory did) but add a second step that standardizes the period of risk exposure

TABLE 7: Fully Disclosed Prototype For Presenting Rate Calculations

	Juvenile Residential Facility Population	*General Population of Adolescents Aged 15 to 19*	*Calculation*
Length of incident observation period	365 days	365 days	
Average length of stay (person observation time)	147 days	365 days	
Average daily population size	106,336	20,219,890	
Total admissions during incident observation period	263,713	20,219,890	
Number of suicides during incident observation period	10	1,611	
Rate of death per 100,000 average daily population per year	9.4	7.9	(Number of suicides per year/average daily population) × 100,000
Rate of death per 100,000 total admissions per year	3.8	7.9	(Number of suicides per year/total admission per year) × 100,000
Rate of death per 100,000 person days per year	9.4	7.9	(Number of suicides per year/total person days) × 100,000
Rate of death per 100,000 daily population per confinement day	0.06	0.02	(Number of suicides per year/[average risk exposure × average daily population]) × 100,000
Rate of death per 100,000 confined young people per confinement year	23.35	7.9	(Rate of death per 100,000 daily population per [confinement] day) × 365

so that the volume of time in which to observe the event in the numerator is equivalent to the period of person-risk exposure of the denominator (see Table 7, rate of death per 100,000 confined young people per confinement year).

Note that Gallagher and Dobrin suggested that this makes for a more intuitive and direct comparison of risks with the general population because both populations now have the same amount of risk exposure.

Observation 3. Rates based on total admissions will always produce lower rates than both beds-based and person-day rates. This is because the number of total admissions will always exceed the average population count on a single day when the length of stay is less than 1 year, barring closure of the facility and other unforeseen events. In turn, the resulting rate is reduced.

DISCUSSION

A rate of 23.35 is ontologically different than a rate of 9.4 (likewise, 57.0 and 1.6), and choosing between them for policy purposes is no simple matter. As demonstrated above, the debate centers on (a) the length of stay in occupied beds and (b) whether to standardize the risk-exposure period so that (a) the numerator and denominator reflect equivalent periods of time and (b) comparisons may be made between populations with fewer than 365 days of risk exposure to those with 365 days of risk exposure.

The admissions-based rates (such as the critics' response to Farr's bed-based rate, and by Flaherty) are not well suited for making comparisons in populations under different periods of observation. This is because they in no way account for the length of exposure to a risk and will always underestimate the rate.

Using an occupied-beds rate (such as Nightingale, Farr, and Snyder did) or the comparable total patient-day rate (e.g., Vandenbroucke & Vandenbroucke-Grauls) to provide yearly risks is clearly preferable to an admissions-based rate. It standardizes for length of stay. The underlying assumptions of these calculations must be fully understood for the rate to have meaning, however. When the length of stay is less than 1 year, but the events of interest are tallied for a 1-year period (as is often the case), then the rate is not calculated for the people in the population but rather the beds (in this case) that are occupied during the 1-year period. Thus, the rate is calculated for a placeholder, making "beds-based" a fitting name because the bed (or placeholder) holding the person assumes the risk. This method requires the assumption that the incoming young people be similar in essence to outgoing young people. This is a reasonable requirement.

The most difficult challenge with the beds-based/total patient-day calculations is making clear to the consumer what units are involved in the rate comparisons. In the general population, the placeholder and the people are generally one and the same because they occupy the beds for 1-year periods. Thus, the general population rate may be considered both a person-based rate and an occupied-beds rate. This is not the case in institutions with high population turnover. The people in the population of interest and the occupied beds observed for the 1-year period are not one and the same: The people are rarely (if ever) observed for the full 1-year period. Thus the facility rates in these cases are strictly occupied-beds rate, not person-based rates. In other words, for facilities, it answers the question: What is the risk of observing a suicide in a facility in a 1-year period?

Gallagher and Dobrin (2006a) also presented a beds-based calculation but adjusted this rate into a person-day rate. They did this, they argued, so that they could estimate the risk of suicide to the young people in the facilities and directly compare suicide in the facility and general populations. Because the young people in the general population are typically observed for the same 1-year periods for which the events are tallied, the resulting person-day and occupied-beds rates are equivalent. Instead of answering the beds-based question, this approach answers the question: What is the risk that a young person will commit suicide in a facility in a 1-year period? This speaks more to the suicidality of the population in question and the effects of the facility on the young people within.

The epidemiological literature accepts the beds-based rate but highlights the added value of the person-time-based incident rates (e.g., Gallagher & Dobrin, 2006a). For example, a leading epidemiological primer (Rothman & Greenland, 1998b, p. 31) provides such an equation.[3] They noted,

> The time contributed by each person to the denominator is sometimes known as the 'time at risk,' that is, time at risk of an event's occurring. Analogously, the people who contribute time to the denominator of an incidence rate are referred to as 'the population at risk.' (Rothman & Greenland, 1998b, p. 32)

Note, however, that there is some ambiguity about the term "length of the period" in the equation noted in endnote 3. Another study more clearly states the meaning as follows:

> Each population member spends a specific amount of time in the studied population over the risk period; the sum of these times in all population members is called the total person-time at risk over the measured period. Person-time represents the observational experience in which disease onsets can be observed. . . . When the risk period is of a fixed length, the total person-time at risk over the period is equal to the average size of the population over the period multiplied by the length of the period. (Bougnèères, 2003, p. 13)

Applied to the Gallagher and Dobrin approach, the "risk period" referred to above is the 1-year facility observation period. The total person time at risk is the average size of the population on a given day multiplied by the length of time at risk (average length of stay).

Debates surrounding this issue are likely to stem from differing interpretations of what is meant by the observation period and the period at risk. After a careful reading of epidemiological literature, we found no unambiguous definitions. We note that there are two ways to interpret the observation period, and we also note that the person-risk is a theoretically different issue.

First, one may consider the observation period as strictly the period of time in which the incidents were counted. This is often the 1-year period. When the population is not in residence for the full observation period or is, as we call it, a high-turnover population, the observation time of the actual individuals is different than the observation time for gathering counts of incidents. Our Observation 2a above demonstrates how the beds-based or total person-day rates inherently use the period of time in which the incidents were counted as the observation period in the denominator. Similarly, applying this to the equation in endnote 3 demonstrates how the period of observation is mathematically cancelled. In other words, the observation period is redundant to the equation—the resulting rate when the denominator is either average population on a given day or the total number of person days is the same, whether or not the observation period is included. It may be helpful to think of this as an incident rate calculation.

The second approach considers the observation period the length of stay and creates a rate that reflects the person-risk incident rate. In other words, the rate is changed by including the person time that each individual has contributed to the total observation time of the incident collection numerator. The Gallagher and Dobrin method is more closely based on the equation in endnote 3. It is useful to think of this is a person-risk incident rate.

CONCLUSION

Making incident rates comparable between those in a high-turnover population and those in a stable population (i.e., little or no moving in and out of the risk group) requires some level of standardization to account for issues of length of stay and risk exposure. Some methods are more precise than others. Which particular standardization method to choose depends in part on the purpose of the exercise.

Each of the calculations explored above provide different methods for standardizing. The admissions-based rate is inferior because it does not in any way account for observation-time issues. It is therefore inappropriate for purposes of calculating suicide rates for juvenile residential facilities.

The beds-based rates (mathematically equivalent to a total patient-days rate) inherently adjust the calculation to account for length of stay. However, it is a placeholder rate—it provides facilities with valuable information about how many suicides occurred given how many beds were occupied. This is useful mostly to facility administrators for quality comparisons because it is an equivalent and standardized rate of the observed incidence of suicide.

In addition, the person-based yearly rate (Gallagher & Dobrin, 2006a) accounts for length of stay and standardizes the observation period between the populations for purposes of direct comparison of the risks to the population. That is, it is more concerned with answering questions about the relative risks of suicide of the young people. The person-based yearly rates will have great value for mental health professionals and others concerned with the potential for suicide in the facility environment. This means that the roughly 80% or so of facilities (Gallagher & Dobrin, 2006a) should continue to improve screening practices and make every effort to reduce facility-level risk factors (Gallagher & Dobrin, 2005, 2006b; Hayes, 2004a).

In all, it is probably best to present all methods of calculation. We provide an example of a fully disclosed prototype for presenting rate calculations in Table 3. This table provides everything necessary for the consumer to make informed choices about what information is most relevant to their purposes.

We note that there are other methods for calculating rates not described here (see, e.g., Rothman & Greenland, 1998c). There are also methods for further adjusting rates beyond the observation-time issues to acknowledge important differences in population characteristics across facilities, referred to as "case-mix" in the epidemiological literature (e.g., Rosenthal, Harper, Quinn, & Cooper, 1997). In other words, it is possible that there are systematic differences across facilities in terms of risk factors related to suicide that need to be accounted for in calculating comparable rates. For example, a facility serving young people diagnosed with major depressive disorders should have a higher risk of observing a suicide compared to other facilities that screen out young people based on mental health diagnoses. Even more straightforward are adjustments that can be made in terms of demographic factors known to be related to the risk of suicide, such as age, sex, and race. The next step for this research is to make case-mix adjustments. It is well beyond the scope of the current work to have included it in this discussion.

Finally, we would be remiss not to note that there are data considerations. Recent work by Hayes (2004b) suggests an underreporting of suicides in facilities, meaning the calculations reviewed here are likely lower than the true rate. In addition, recent data not yet released suggest that the suicide count in facilities has increased by 50% since the last census administration (Gallagher, 2006). This means that even the prior beds-based rates will be significantly increased over the Snyder calculations. Future work must address differences in rates across facility types as exposure periods and case mix vary vastly depending on the purpose of the facility.

NOTES

1. The phrase "general population" will always refer to the population of nonincarcerated juvenile inhabitants of the United States.

2. All rates are per 100,000 per year. However, the units vary and include admissions, occupied beds, and children-confinement days.

3. Disease onsets ÷ (average size of population × length of the period) = person-time incident rate.

REFERENCES

American Academy of Child and Adolescent Psychiatry. (2001). Practice parameter of the assessment and treatment of children and adolescents with suicidal behavior. *Journal of the American Academy of Child and Adolescent Psychiatry, 40*(Suppl.), 24S.

Arias, E., Anderson, R. N., Kung, H. S., Murphy, S. L., & Kochanek, K. D. (2003). Deaths: Final data for 2001. *National Vital Statistics Report, 52,* 1-100.

Bougnèères, P. (2003). Incidence of type 1 diabetes in European children [Review of Green & Patterson (2001)]. *International Diabetes Monitor*, *15*(1), 13-14.

Elandt-Johnson, R. C. (1975). Definition of rates: Some remarks on their use and misuse. *American Journal of Epidemiology*, *102,* 267-271.

Farr, W. (1864a, February). Miss Nightingale's "Notes on Hospitals." *Medical Times and Gazette*, pp. 186-187.

Farr, W. (1864b, April). Mortality in hospitals. *Lancet,* pp. 420-422.

Flaherty, M. (1980). *An assessment of the national incidence of juvenile suicides in adult jails, lockups, and juvenile detention centers.* Champaign, IL: Community Research Forum.

Gallagher, C. A. (2006, November). *Suicide and suicide-related injuries in juvenile justice residential facilities.* Paper presented to the annual meeting of the American Public Health Association, Boston.

Gallagher, C. A., & Dobrin, A. (2005). The association between suicide screening in juvenile justice residential facilities and suicide attempts requiring emergency care. *The Journal of the American Academy of Child and Adolescent Psychiatry, 44*, 485-493.

Gallagher, C. A., & Dobrin, A. (2006a). Deaths in juvenile justice residential facilities, 2002 and 2004. *Journal of Adolescent Health, 38*, 662-668.

Gallagher, C. A., & Dobrin, A. (2006b). Facility-level characteristics associated with serious suicide attempts and deaths from suicide in juvenile justice residential facilities, 2000 and 2002. *Suicide and Life-Threatening Behavior, 36*(3)*,* 353-386.

Gerstman, B. B. (2003). Comments regarding "*On prognosis*" by William Farr (1838), with reconstruction of his longitudinal analysis of smallpox recovery and death rates. *Soz-Präventmed, 48,* 285-289.

Green, A., & Patterson, C. C. (2001). Trends in the incidence of childhood-onset diabetes in Europe 1989-1998. *Diabetologia, 44*(Suppl. 3), B3-B8.

Hayes, L. M. (2004a). Guide to developing and revising suicide prevention protocols. In National Commission on Correctional Health Care (Ed.), *Standards for health services in juvenile detention and confinement facilities* (pp. 171-176). Chicago: National Commission on Correctional Health Care.

Hayes, L. M. (2004b). *Juvenile suicide in confinement: A national survey*. Mansfield, MA:National Center on Institutions and Alternatives.

Holmes, T. (1864, April). Mortality in hospitals. *Lancet,* pp. 451-452.

Iezzoni, L. I. (1996a). 100 apples divided by 15 red herrings. *Annals of Internal Medicine*, *124*, 1079-1085.

Iezzoni, L. I. (1996b). In defense of Farr and Nightingale. *Annals of Internal Medicine*, *125*, 1014.

Iezzoni, L. I. (1996c). A return to Farr and Nightingale. *Annals of Internal Medicine, 127,* 170-171.

Memory, J. (1989). Juvenile suicides in secure detention facilities: Correction of published rates. *Death Studies, 13,* 455-463.

National Center for Health Statistics. (2004). *Mortality tables*. Centers for Disease Control and Prevention. Retrieved March 8, 2004, from http://www.cdc.gov/nchs/datawh/statab/unpubd/mortabs.htm

National Commission on Correctional Health Care (NCCHC). (2004). *Standards for health services in juvenile detention and confinement facilities*. Chicago: Author.

National Institute of Mental Health, National Institutes of Health. (2004). *Suicide deaths, U.S., 2001.* Retrieved March 8, 2004, from http//www.nimh.nih.gov/research/suifact.cfm

Nightingale, F. (1863). *Notes on hospitals* (3rd ed.). London: Longman, Green, Longman, Roberts and Green.

Parent, D. G., Letter, V., Kennedy, S., Livens, L., Wentworth, D., & Wilcox, S. (1994). *Conditions of confinement: Juvenile detention and correction facilities.* Washington, DC: Office of Juvenile Justice and Delinquency Prevention (OJJDP).

Pennsylvania Health Care Cost Containment Council. (2005). Hospital-acquired infections in Pennsylvania. *Pennsylvania Health Care Cost Containment Council Research Briefs, 5*.

Rosenthal, G. E., Harper, D. L., Quinn, L. M., & Cooper, G. S. (1997). Severity-adjusted mortality and length of stay in teaching and nonteaching hospitals. Results of a regional study. *Journal of the American Medical Association, 278,* 485.

Rothman, K. J., & Greenland, S. (1998a). The emergence of modern epidemiology. In K. J. Rothman & S. Greenland (Eds.), *Modern epidemiology* (2nd ed., pp. 3-6). Philadelphia: Lippincott-Raven.

Rothman, K. J., & Greenland, S. (1998b). Measures of disease frequency. In K. J. Rothman & S. Greenland (Eds.), *Modern epidemiology* (2nd ed., pp. 29-46). Philadelphia: Lippincott-Raven.

Rothman, K. J., & Greenland, S. (1998c). *Modern epidemiology* (2nd ed.). Philadelphia: Lippincott-Raven.

Sickmund, M. (2002). *Juvenile residential facility census, 2000: Selected findings.* Washington, DC: OJJDP, U.S. Department of Justice.

Snyder, H. (2005). Is suicide more common inside or outside of juvenile facilities? (Research Note). *Corrections Today, 67,* 84-88.

U.S. Census Bureau. (2001). *Age: 2000 Census, 2000 brief*. Washington, DC: U.S. Department of Commerce, Economics and Statistics Administration.

Vandenbroucke, J. P. (2003). Continuing controversies over "risks and rates"—more than a century after William Farr's "*On prognosis.*" *Soz-Präventmed, 48,* 216-218.

Vandenbroucke, J. P., & Vandenbroucke-Grauls, C. M. (1996). In defense of Farr and Nightingale. *Annals of Internal Medicine, 125,* 1014.

Vandenbroucke, J. P., & Vandenbroucke-Grauls, C. M. (1997). A return to Farr and Nightingale. *Annals of Internal Medicine, 127,* 170-171.