Survival after blood transfusion

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BACKGROUND: Long-term survival of transfusion recipients has rarely been studied. This study examines short- and long-term mortality among transfusion recipients and reports these as absolute rates and rates relative to the general population.

STUDY DESIGN AND METHODS: Population-based cohort study of transfusion recipients in Denmark and Sweden followed for up to 20 years after their first blood transfusion. Main outcome measure was all-cause mortality.

RESULTS: A total of 1,118,261 transfusion recipients were identified, of whom 62.0 percent were aged 65 years or older at the time of their first registered transfusion. Three months after the first transfusion, 84.3 percent of recipients were alive. One-, 5-, and 20-year posttransfusion survival was 73.7, 53.4, and 27.0 percent, respectively. Survival was slightly poorer in men than in women, decreased with increasing age, and was worst for recipients transfused at departments of internal medicine. The first 3 months after the first transfusion, the standardized mortality ratio (SMR) was 17.6 times higher in transfusion recipients than in the general population. One to 4 years after first transfusion, the SMR was 2.1 and even after 17 years the SMR remained significantly 1.3-fold increased.

CONCLUSION: The survival and relative mortality patterns among blood transfusion recipients were characterized with unprecedented detail and precision. Our results are relevant to assessments of the consequences of possible transfusion-transmitted disease as well as for cost-benefit estimation of new blood safety interventions.

Information on survival patterns of transfusion recipients is essential for the continued assessment of transfusion-transmitted diseases and thus to the implementation of new and often expensive screening techniques.[1-4] However, long-term survival of transfusion recipients has only been sparsely studied and accordingly remains poorly characterized. The largest study to date reported cumulative survival estimates and crude mortality rates for 6779 recipients in the period up to 5 years after the transfusion event.[5] To our knowledge, information on longer follow-up, 7 and 10 years, is available only from two smaller cohorts of 932 and 802 transfusion recipients, respectively.[6,7] The need for precise information is emphasized by suggested secular trends in recipient survival[6,7] and by the realization that some transfusion-related complications possibly become manifest only decades after the transfusion event, for example, variant Creutzfeldt-Jakob disease.[8]

ABBREVIATIONS: SCANDAT = Scandinavian Donation and Transfusion; SMR = standardized mortality ratio.

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In the absence of reliable or sufficiently detailed survival data, estimates of cost-effectiveness of proposed screening techniques often rely on crude assumptions about transfused patients' mortality, for example, a constant mortality probability more than 3 years after transfusion[9] or a mortality that would resemble that of the general population 5 years after transfusion.[10] While the underlying conditions necessitating blood transfusion in the recipient make this latter assumption unlikely, comparisons of transfusion recipients' mortality rates with those prevailing in the general population are scarcely available in the literature, neither overall nor with respect to specific causes.[8,11] We assessed both absolute and relative mortality after transfusion using a Danish-Swedish population–based register encompassing more than 1.1 million transfusion recipients that were followed for up to 20 years after their first recorded blood transfusion.

MATERIALS AND METHODS

In Sweden and Denmark, blood banks are part of the hospitals they serve, and thus they are a part of the public health care sector. Blood banks register the identity of all blood donors, all blood donations, and all blood components issued to patients, as well as the identity of all recipients. In both Sweden and Denmark, computerized systems to record this information have been used in an increasing number of blood banks since the late 1960s, with complete national coverage achieved by 1996 in Sweden and 2002 in Denmark.[12] As part of the Scandinavian Donation and Transfusion (SCANDAT) database project, we collected all electronic information on donors and recipients available from Swedish and Danish blood banks. Whereas data were available for the entire period since 1966 in Sweden, Danish data were available only since 1982 because early computer systems were based on reusable tapes.[12]

Since 1947 and 1968, respectively, all residents in Sweden and Denmark have been assigned unique national registration numbers. All national registries containing identifiable information are based on the national registration numbers, which thus serves as a unique key for register-based linkage studies. For all persons recorded in the SCANDAT database, we used Swedish and Danish population registries[13,14] to obtain vital status as of December 31, 2002, and if applicable, the date of death or emigration. Analogously, information about causes of death was obtained from the national cause-of-death registers.[15,16] Also as part of the SCANDAT project, information about hospitalizations, including department and primary and secondary discharge diagnoses, coded according to the International Classification of Diseases,[17] Versions 6 through 10, and surgical and other procedures, were obtained for all individuals in the database through linkage with the Danish and Swedish nationwide hospital discharge registries.[18,19] The creation of the SCANDAT database and the conduction of this study were approved by appropriate scientific ethical committees and data protection agencies in both countries. Mortality data for the general Danish and Swedish populations according to country, sex, age, and calendar period were obtained from the World Health Organization.[20]

Follow-up

For technical reasons relating to the initiation of computerization and to optimize comparability between Denmark and Sweden, information on recipients whose first transfusion was before January 1, 1983, was disregarded in both countries. Follow-up of the recipients started on the day of the first registered transfusion of any blood component and ended on the day of death, emigration, or December 31, 2002, whichever came first. In this study, a blood transfusion was defined as transfusion of one blood component emanating from one or more donors. A transfusion episode constituted a period of transfusions, separated from previous or subsequent transfusions by intervals of at least 7 days of no transfusion activity.[21] Blood components included red blood cells (RBCs), fresh-frozen plasma (FFP), platelets (PLTs), and unknown or other components. For reasons of register completeness, follow-up ended in 2000 in analyses of cause-of-death–specific and relative mortality.

Statistical analyses

Cumulative survival according to time since first transfusion was estimated by Kaplan-Meier methodology using the LIFETEST procedure in computer software (SAS v. 9.1, SAS Institute, Cary, NC).[22] Cumulative survival was estimated overall for the entire cohort of transfusion recipients and stratified by country, sex, age at first transfusion (0-19, 20-39, 40-64, 65-79, or 80+ years), calendar period at first transfusion (1983-1987, 1988-1992, 1993-1997, or 1998-2002), department of first transfusion (internal medicine, surgery, gynecology and obstetrics, other and unclassifiable, or unknown), and cumulative number of transfused units received during the first month after first transfusion (1-2, 3-4, 5-10, or 11+) as a time-varying covariate. Thus, in the latter case the same person may contribute follow-up time in several strata and a death in at most one stratum. The necessary calculations were done using a home-grown macro for stratification and aggregation of events and follow-up time in conjunction with a data step emulating the functionality of the LIFETEST procedure. Cumulative survival was expressed as percentages. Adjusted relative mortality assessed as incidence rate ratios were estimated by log-linear Poisson regression and associated 95 percent confidence intervals (CI).

We also estimated the recipients' risk of dying relative to the risk in the general Danish and Swedish populations. Specifically, the relative risk of dying was expressed as the standardized mortality ratio (SMR), where the observed number of deaths is compared to the number expected based on mortality rates in the general populations in strata defined by country, sex, 5-year age-group, and 1-year calendar period. Population data were available for ages 0 to 90 years for the calendar period 1983 through 2000.[20] SMRs were estimated with the logarithm of the expected number of cases as offset in the GENMOD procedure in SAS. Owing to the huge sample size, we did not find it meaningful to conduct statistical tests for homogeneity and we chose not to present the upper and lower 95 percent confidence limits (which were practically indistinguishable) for the cumulative survival and SMRs presented in the figures and tables. To estimate the impact of assuming, as done in previous publications, that the mortality in transfusion recipients 5 years after transfusion is similar to that in the general population, we calculated the percentage difference between the number of deaths observed in our cohort and the expected number of deaths in the general Danish and Swedish population 5 to 20 years after first recorded transfusion.

TABLE 1. Characteristics of transfusion recipients according to country and covariates

Characteristic	Denmark	Sweden	Total cohort
Total*	346,071 (31.0)	772,190 (69.0)	1,118,261 (100)
Sex†			
Men	155,502 (44.9)	344,868 (44.7)	500,370 (44.8)
Women	190,569 (55.1)	427,322 (55.3)	617,891 (55.2)
Age (years) at first transfusion†			
0-19	11,814 (3.4)	27,299 (3.5)	39,113 (3.5)
20-39	28,945 (8.4)	70,050 (9.1)	98,995 (8.9)
40-64	96,279 (27.8)	190,309 (24.7)	286,588 (25.6)
65-79	127,901 (37.0)	297,896 (38.6)	425,797 (38.1)
80+	81,132 (23.4)	186,636 (24.1)	267,768 (23.9)
Period at first transfusion†			
1983-1987	19,090 (5.5)	97,455 (12.6)	131,663 (11.4)
1988-1992	42,194 (12.2)	129,172 (16.7)	178,984 (15.5)
1993-1997	106,326 (30.7)	252,271 (32.7)	364,474 (31.7)
1998-2002	178,461 (51.6)	293,292 (38.0)	476,553 (41.4)
Department of first transfusion†			
Surgery	173,488 (50.1)	478,380 (62.0)	651,868 (58.3)
Internal medicine	124,884 (36.1)	176,508 (22.9)	301,392 (27.0)
Gynecology and obstetrics	19,058 (5.5)	56,242 (7.2)	75,300 (6.7)
Other and unclassifiable	2191 (0.6)	5492 (0.7)	7683 (0.7)
Unknown	26,450 (7.7)	55,568 (7.2)	82,018 (7.3)

* Data are reported as number (row percent).
† Data are reported as number (column percent).

RESULTS

Transfusion recipients

A total of 1,118,261 transfusion recipients was identified, and these received a total of 9,979,082 units during 2,172,917 transfusion episodes. Seventy-two percent of all transfused components were RBCs, 19 percent were FFP, 7 percent were PLTs, and the remaining 2 percent were other components including whole blood. The first registered transfusion was autologous for 5588 (0.5%) recipients and the donor was unknown for 60,028 (5.4%) recipients. Table 1 shows characteristics of transfusion recipients according to country and covariates. The majority of transfusion recipients (69.0%) lived in Sweden, reflecting the earlier introduction of computerized blood bank systems and a larger population. In both countries, more women than men were transfused.

Median age at first transfusion was 69.9 (interquartile range, 55.3-79.4) and 70.9 (interquartile range, 56.3-79.7) in Denmark and Sweden, respectively. Age at first registered transfusion increased over time in the cohort. For calendar periods 1983 through 1987, 1988 through 1992, 1993 through 1997, and 1998 through 2002 median ages at first transfusion were 63.9, 68.2, 71.4, and 72.5 years, respectively. Overall, 62.0 percent of the transfused patients were 65 years or older at first transfusion.

The distribution of transfusion recipients according to calendar period at first transfusion differed between Denmark and Sweden, reflecting the introduction of computerized blood bank systems at different times. In the total cohort, 73.1 percent of recipients had a transfusion registered for the first time during the period 1993 through 2002. The majority of recipients were transfused for the first time while admitted to surgical departments, followed by departments of internal medicine, with the difference being more pronounced in Sweden (Table 1).

Cumulative survival

Cumulative survival by time since first transfusion stratified by covariates is shown in Table 2. Overall, 84.3 percent (95% CI, 84.2%-84.3%) of transfusion recipients were alive 3 months after their first transfusion, while 73.7 percent (95% CI, 73.6%-73.8%) were alive after 1 year. Five-year survival was 53.4 percent (95% CI, 53.3%-53.5%) and 20-year survival 27.0 percent (95% CI, 26.8%-27.2%). At all times after first transfusion, Danish recipients had poorer survival than Swedish recipients, which persisted even after adjustment for calendar period, age, sex department of first transfusion, and cumulative number of units received (data not shown). Also, men had poorer survival than women. Cumulative survival also varied by

TABLE 2. Cumulative survival (%) after first transfusion according to time since first transfusion and covariates

	Time since first transfusion						
Covariate	3 months	6 months	1 year	5 years	10 years	15 years	20 years
Overall	84.3	79.5	73.7	53.4	40.3	32.2	27.0
Country							
Denmark	80.6	75.2	68.8	47.5	35.0	27.5	22.6
Sweden	85.9	81.4	75.9	55.9	42.5	34.1	28.6
Sex							
Men	81.6	76.2	69.9	49.5	36.3	27.5	21.9
Women	86.5	82.1	76.9	56.5	43.6	36.2	31.2
Department of first transfusion							
Surgery	87.0	83.2	78.3	57.7	42.1	31.7	24.6
Internal medicine	74.8	67.6	59.3	35.5	24.4	18.8	15.1
Gynecology and obstetrics	96.5	95.1	93.0	86.2	83.2	80.8	78.1
Other and unclassifiable	78.7	73.5	67.1	42.5	26.8	20.9	18.2
Unknown	86.1	79.8	72.7	52.9	41.1	33.9	29.3
Number of units*							
1-2	87.1	82.3	76.6	55.8	43.0	35.8	31.5
3-4	84.7	79.6	73.5	52.0	38.4	29.9	24.5
5-10	80.6	75.7	70.2	50.6	37.2	28.4	22.2
11+	68.1	64.4	59.9	45.1	34.0	25.6	19.3

* Cumulative number of units received during the first month after first transfusion estimated as a time-varying covariate.

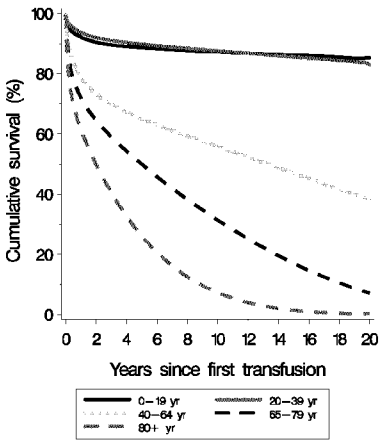

Fig. 1. Cumulative survival (%) according to time since first transfusion and age at first transfusion.

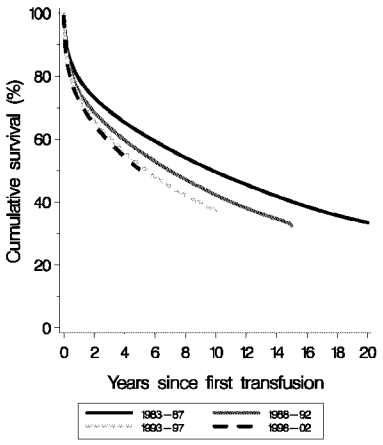

Fig. 2. Cumulative survival (%) according to time since first transfusion and calendar period at first transfusion.

department of first transfusion. Women transfused at departments of gynecology and obstetrics had the best survival, whereas patients transfused at departments of internal medicine had the worst. Poorer survival among Danish recipients was observed at all types of departments (data not shown). At all times since first transfusion, survival was negatively associated with increasing number of units received during the first month after first transfusion. Twenty years after first transfusion, only 19.3 percent (95% CI, 18.7%-19.9%) of those who received 11 units or more were alive compared with 31.5 percent (95% CI, 31.2%-31.8%) of those who received only 1 to 2 units.

As illustrated in Fig. 1 showing cumulative survival by time since first transfusion for different age groups, increasing age at first transfusion was associated with worse survival, with the exception of recipients aged 0 to 19 years who had slightly worse survival than recipients aged 20 to 39 years. One-year survival was 92.1 percent (95% CI, 91.9%-92.4%) in 0- to 19-year-olds, 93.6 percent (95% CI, 93.5%-93.8%) in 20- to 39-year-olds, 78.6 percent (95% CI, 78.4%-78.7%) in 40- to 64-year-olds, 71.9 percent (95% CI, 71.7%-72.0%) in 65- to 79-year-olds, and 61.3 percent (95% CI, 61.1%-61.5%) in recipients aged 80 years or more.

Figure 2 shows that absolute survival decreased by calendar period of first transfusion. Among recipients transfused in 1983 through 1987, 1-year survival was 79.1 percent (95% CI, 78.9%-79.4%). Corresponding figures for 1988 through 1992, 1993 through 1997, and 1998 through

2002 were 75.2 percent (95% CI, 75.0%-75.4%), 73.3 percent (95% CI, 73.1%-73.4%), and 72.1 percent (95% CI, 72.0%-72.3%), respectively. Analysis of survival for different calendar periods revealed that when adjusted for time since first transfusion, age, sex, country, department of first transfusion, and cumulative number of units received, there were no significant differences between the different calendar periods (data not shown).

Relative mortality

The SMR of transfusion recipients relative to the general population by time after first transfusion and covariates are shown in Table 3. Overall, the SMR was 17.6 (95% CI, 17.5-17.7) times higher in the transfused cohort during the first 3 months after first transfusion, meaning that during the first 3 months after first transfusion recipients had a 17.6 times higher risk of dying compared with a person in the general population with similar demographic characteristics, that is, from the same country, of the same age and sex, and during the same calendar period. The SMR was 2.1 (95% CI, 2.1-2.1) in the period from 1 to 4 years after first transfusion and even 15 to 17 years after first transfusion a significantly increased SMR of 1.3 (95% CI, 1.2-1.4) persisted. The relative mortality of transfusion recipients was slightly higher in Denmark than in Sweden for the first 10 years after first transfusion and slightly higher for men than for women.

Irrespective of the type of department at which the first transfusion was administered, the relative risk of dying was the highest shortly after transfusion. With continued follow-up, patients transfused at departments of internal medicine continued to have the highest relative risk of dying, whereas women transfused at departments of gynecology and obstetrics had only a slightly increased risk of dying 10 years or more after the transfusion event. Increasing number of units received during the first month after first transfusion was associated with increasing mortality relative to the general population. While being most pronounced shortly after first transfusion, this was true at all times since first transfusion. Cause-of-death–specific SMRs showed that the increased relative mortality applied to all causes of death and were highest for digestive, neoplastic, and infectious diseases.

Figure 3 shows SMRs according to time since first transfusion for different age groups. During the first years after a transfusion, the SMR was markedly increased for all age groups, although most for the youngest age groups. Even after more than 15 years of follow-up, an excess mortality was observed in transfusion recipients; the younger the recipient was at time of first transfusion the higher the persistent excess mortality.

TABLE 3. SMR of transfusion recipients relative to the general population, according to time since first transfusion and covariates

	Time since first transfusion						
Covariate	0-2 months	3-5 months	6-11 months	1-4 years	5-9 years	10-14 years	15-17 years
Overall	17.6	6.0	3.9	2.1	1.5	1.4	1.3
Country							
Denmark	21.0	6.7	4.4	2.4	1.6	1.4	1.4
Sweden	16.2	5.7	3.8	2.0	1.5	1.4	1.3
Sex							
Men	19.1	6.3	4.1	2.1	1.5	1.4	1.3
Women	16.1	5.7	3.8	2.1	1.5	1.4	1.3
Department of first transfusion							
Surgery	12.9	4.2	2.8	1.7	1.4	1.4	1.3
Internal medicine	29.6	10.2	6.8	3.6	2.4	2.1	1.7
Gynecology and obstetrics	22.0	10.2	8.3	4.1	1.5	1.1	1.2
Other and unclassifiable	18.8	5.0	3.5	2.2	2.4	1.7	1.0
Unknown	16.8	8.5	5.3	2.3	1.4	1.3	1.3
Number of units*							
1-2	14.2	5.5	3.7	2.1	1.5	1.3	1.1
3-4	15.4	6.0	3.9	2.1	1.5	1.4	1.3
5-10	20.6	6.4	4.1	2.1	1.6	1.5	1.4
11+	48.7	8.5	5.5	2.6	1.8	1.7	1.7
Cause of death							
Infectious disease	31.5	6.3	3.7	2.2	1.7	1.5	1.7
Neoplastic disease	36.3	17.0	10.7	3.8	1.6	1.4	1.2
Cardiovascular disease	9.0	2.5	1.7	1.5	1.4	1.4	1.4
Respiratory disease	8.7	2.4	1.9	1.5	1.4	1.2	1.1
Digestive disease	49.9	6.3	3.9	2.7	2.1	1.8	1.3
Other diseases	17.0	3.9	2.7	2.0	1.6	1.5	1.2

* Cumulative number of units received during the first month after first transfusion estimated as a time-varying covariate.

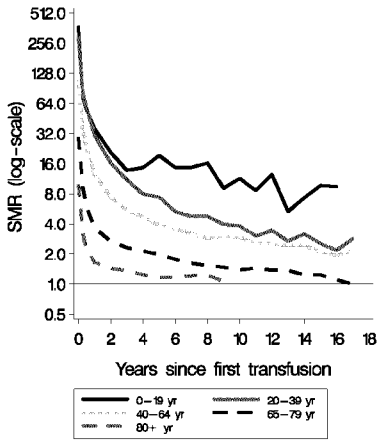

Fig. 3. Survival of transfusion recipients relative to the general population (SMR) according to age at first transfusion.

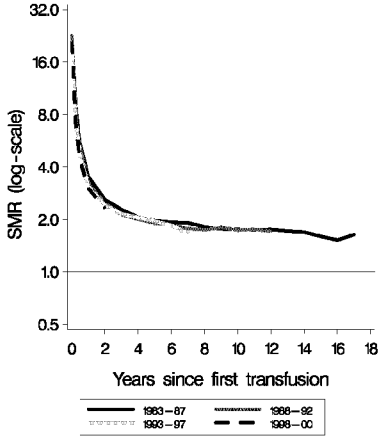

Fig. 4. Survival of transfusion recipients relative to the general population (SMR) according to calendar period at first transfusion.

As illustrated in Fig. 4, the decrease in excess SMR of transfusion recipients after a transfusion was comparable in recipients transfused in different calendar periods. Assuming the mortality pattern in transfusion recipients 5 years after transfusion is similar to that of the general population, we underestimated the number of deaths by 33 percent.

DISCUSSION

In this study, we took advantage of information about more than 1.1 million transfusion recipients registered in databases in Swedish and Danish blood banks in the calendar period between 1983 and 2002. Combined with data from nationwide population and cause-of-death registries, we were able to characterize patterns of both absolute and relative survival after transfusion with unprecedented precision.

Although practically and ethically challenging to study, it has been suggested that blood transfusion in itself may increase the risk of death in critically ill patients.[23] While the design of our study did not allow us to investigate this, we believe that the poor survival after blood transfusion demonstrated in this study reflects that transfusions are given to patients who already are at increased risk of dying from, for example, trauma, major operations, or serious illness.

Consistent with previous studies, absolute mortality was high in the period shortly after blood transfusion. The excess relative mortality among transfusion recipients was not restricted to the period shortly after first transfusion, but was apparent even 17 years after first transfusion. As in previous studies, determinants of a decreased absolute survival included male sex and old age.[6-8,11,24] Although survival is also lower in men than in women in the general population, the relative measure of mortality revealed that the excess mortality among transfusion recipients was more pronounced in men than in women. Despite decreasing absolute survival with increasing age, mortality among transfusion recipients relative to the general population was highest in the youngest age group. As also suggested in earlier surveys,[5-8,11,24] the absolute survival of transfusion recipients decreased in more recent calendar periods. This is likely to in part reflect the increasing age of the recipients since we observed no differences between different calendar periods after adjusting for age, sex, and country. Accordingly, we found no indication that survival among transfusion recipients decreased in more recent periods.

In addition to old age, male sex, and recent calendar period transfusion recipients' mortality was also influenced by the condition necessitating blood transfusion and by the number of units received. With the use of department at first transfusion as a crude proxy measure of indication, patients admitted to departments of internal medicine had the highest mortality, both absolute and relative to the general population. Similarly, patients receiving most transfusions were at highest risk of dying. On both absolute and relative scales, the lowest mortality was observed among women receiving transfusions at obstetric and gynecologic departments. Absolute mortality was high due to cardiovascular and neoplastic diseases and low due to infectious, respiratory, and digestive diseases. However, relative to the general population mortality due to infectious and digestive diseases was markedly elevated in transfusion recipients. As expected, relative mortality was also markedly increased for neoplastic diseases. This observed variation in absolute mortality is consistent with previous findings.[6-8,11,24]

A higher absolute mortality in Denmark compared with Sweden is a general phenomenon, not limited to

transfusion recipients. Generally, the higher absolute mortality in Denmark is ascribed to a higher level of tobacco smoking and alcohol consumption.[25] SMRs stratified by country showed marginally lower SMRs in Swedish recipients than in Danish recipients. This difference is not readily explained, but presumably is not related to more strict transfusion criteria in Denmark, as more transfusions are administered in Denmark than in Sweden relative to the population size.[12] Adjusted analyses revealed that the higher mortality in Denmark could not be attributed to differences in calendar period, age, sex, department of first transfusion, or cumulative number of units received.

Absolute survival estimates more than 10 years after first blood transfusion have not previously been available, nor have comparisons with expected mortality to any greater extent.[8,11] The most important finding presented in this regard is the substantial long-term survival indicating that even transfusion-transmitted diseases with very long incubation periods can potentially affect a considerable number of individuals.[26] Overall, our analyses also revealed that the recipients continued to have a 30 percent increased mortality relative to the general population 15 to 17 years after first transfusion. On the other hand, transfusion-transmitted infectious agents would accumulate in patients receiving multiple transfusions and the long-term survival of these patients is as shown in the present analyses markedly lower than other recipients' survival. Accordingly, both estimates of long-term survival of transfusion recipients and the uneven distribution by number of transfused units should ideally be factored in future policy decisions and cost-effectiveness calculations.

A number of factors related to blood transfusion therapy vary both between and within countries and over time.[27] This includes blood product manufacturing procedures, treatment regimes, private/public health care system, and blood transfusion policies. Even within countries, different indications for transfusion likely exist in different hospitals for the same patient categories.[28] Furthermore, transfusion criteria have likely changed over time in individual hospitals, for example, as a result of the human immunodeficiency virus (HIV) epidemic. Accordingly, the higher age of recipients transfused in later calendar periods in our study may reflect more strict transfusion criteria after the onset of the HIV epidemic and/or more aggressive treatment even in elderly patients. Our findings therefore highlight the need for caution in making direct comparisons of absolute survival between studies.

Our population-based cohort was very large, because it comprised all transfusion recipients in Denmark and Sweden from January 1, 1983, for whom computerized transfusion records existed. Because of the continuously updated civil registration systems in both countries, there was virtually no loss to follow-up. However, nationwide or near nationwide coverage was not achieved until the late 1990s in the two countries. It is possible, therefore, that some recipients, especially in the older age groups, received transfusion before inclusion in the current cohort and thus have had a longer survival than we have estimated. We could, on the other hand, also have missed some transfusion recipients altogether if they had died before inclusion, and this would result in an increased proportion of "survivors" in the early cohort. The differences in the Danish and Swedish part of the data regarding the distribution of departments of first transfusion are also affected by the gradually increasing national coverage in the two countries. Transfusion of whole blood was administered in Denmark and Sweden until the beginning of the 1980s, at which time blood component therapy was introduced.

We had access to detailed mortality rates for the general populations and could therefore produce SMRs in addition to absolute survival estimates. In theory, our estimates would be biased toward unity, that is, be conservative, as the available background mortality rates are based on the total population, which includes deaths in transfusion recipients. Finally, it must be emphasized that no analyses were performed of the indication for transfusion and that we did not intend to study the possible effects of blood transfusion itself on survival. Had the scope of our study been etiologic rather than descriptive, a group of patients with similar characteristics who did not receive transfusion would be a more suitable group for comparison than the general population.

In conclusion, our study contributes new information on both short- and long-term survival of transfusion recipients. Our results provide information to improve assessments of the consequences of possible transfusion-transmitted disease, as well as estimates of cost-benefit of new screening techniques. Furthermore, our work emphasizes that any comparisons of survival of recipients between studies requires in-depth knowledge of the composition of the transfusion recipient cohorts.

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