Check for updates

Accepted Article

DR. KRIS DENHAERYNCK (Orcid ID : 0000-0003-0304-5928)

Article type : Original Article

Pre-transplant Social Adaptability Index and clinical outcomes in renal transplantation – The Swiss Transplant Cohort Study

Denhaerynck Kris, PhD, RN[1], Goldfarb-Rumyantzev Alexander S, MD, PhD[2], Sandhu Gurprataap, MD[3], Beckmann Sonja, PhD, RN[1,4], Huynh-Do Uyen, MD[5], Binet Isabelle, MD[6], De Geest Sabina, PhD, RN[1,7] *for the Psychosocial Interest Group[8], Swiss Transplant Cohort Study[9]*

[1] Institute of Nursing Science, Department of Public Health, University of Basel, Switzerland

[2] Harvard Medical School, Beth Israel Deaconess Medical Center, Boston, USA

[3] Department of Medicine, University of Pittsburgh Medical Center, Pittsburgh, USA

[4] Center of Clinical Nursing Science, University Hospital Zurich, Switzerland

[5] Department of Nephrology and Hypertension, University Hospital Inselspital, Bern, Switzerland

[6] Nephrology and Transplantation Medicine, Cantonal Hospital, St Gallen, Switzerland

[7] Academic Center of Nursing and Midwifery, Department of Public Health and Primary Care, KU Leuven, Belgium

[8] Gaëlle Brack, Anita Büttiker, Sabina De Geest, Kris Denhaerynck, Petra Künzler, Lynn Leppla, Janette Ribaut (University of Basel); Annette Boehler, Michael Koller (University Hospital Basel); Nadine Beerli, Oliver Mauthner (University of Basel, University Department of Geriatric Medicine Felix Platter); Lut Berben (University Children's Hospital Basel); Uyen Huynh-Do (University Hospital Inselspital Bern); Aurelia Mercay (University Hospital Geneva); Karine Hadaya (University Hospital Geneva); Annina Seiler, Joelle Lynn Dreifuss (University Hospital Zurich); Isabelle Binet (Cantonal Hospital St. Gallen); Patrizia Künzler-Heule (University of Basel, Cantonal Hospital St. Gallen); Hanna Burkhalter (Kantonsspital Graubünden), Marian

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/CTR.14218

This article is protected by copyright. All rights reserved

Struker (Kinderspital Zürich), Sonja Beckmann (University of Basel, University Hospital Zurich), Christian Rothlisberger (patient representative)

[9] Patrizia Amico, Andres Axel, John-David Aubert, Vanessa Banz, Beckmann Sonja, Guido Beldi, Christian Benden, Christoph Berger, Isabelle Binet, Pierre-Yves Bochud, Sanda Branca, Heiner Bucher, Thierry Carrel, Emmanuelle Catana, Yves Chalandon, Sabina de Geest, Olivier de Rougemont, Michael Dickenmann, Joëlle Lynn Dreifuss, Michel Duchosal, Thomas Fehr, Sylvie Ferrari-Lacraz, Christian Garzoni, Paola Gasche Soccal, Christophe Gaudet, Emiliano Giostra, Déla Golshayan, Karine Hadaya, Jörg Halter, Dimitri Hauri, Dominik Heim, Christoph Hess, Sven Hillinger, Hans Hirsch, Patricia Hirt, Günther Hofbauer, Uyen Huynh-Do, Franz Immer, Michael Koller (Head of the data center), Bettina Laesser, Brian Lang, Roger Lehmann, Alexander Leichtle, Christian Lovis, Oriol Manuel, Hans-Peter Marti, Pierre Yves Martin, Michele Martinelli, Katell Mellac, Aurélia Merçay, Karin Mettler, Pascal Meylan, Nicolas Mueller (Chairman Scientific Committee), Antonia Müller, Thomas Müller, Ulrike Müller-Arndt, Beat Müllhaupt, Mirjam Nägeli, Manuel Pascual (Executive office), Klara Posfay-Barbe, Juliane Rick, Anne Rosselet, Simona Rossi, Silvia Rothlin, Frank Ruschitzka, Urs Schanz, Stefan Schaub, Aurelia Schnyder, Macé Schuurmans, Federico Simonetta, Katharina Staufer, Susanne Stampf, Jürg Steiger (Head, Excecutive office), Guido Stirniman, Christian Toso, Christian Van Delden (Executive office), Jean-Pierre Venetz, Jean Villard, Madeleine Wick (STCS coordinator), Markus Wilhlem, Patrick Yerly

Address of correspondence: Sabina De Geest, PhD, RN. Institute of Nursing Science, Department Public Health, University of Basel, Bernoullistrasse 28, CH-4056 Basel, Switzerland. Telephone: ++41 (0)61-207 09 51; FAX: ++41 (0)61-207 09 55; Email: sabina.degeest@unibas.ch

Running head: The SAI in kidney transplantation

Disclosures: The authors declare no conflicts of interest.

Funding: The Swiss Transplant Cohort Study is funded by a grant from the Swiss National Research Foundation (Grant number 148512). This work is further supported by unrestricted research grants from Astellas (CH & Europe), Roche (CH) and Novartis (CH).

Data availability statement: Data are available on request from the authors

This article is protected by copyright. All rights reserved

Abbreviations

CH, Confederatio Helvetica

CHF, Swiss Franc

IQR, InterQuartile Range

HIV, Human Immunodeficiency Virus

HR, Hazard Ratio

NHANES, National Health and Nutrition Examination Survey

PSQ, Psychosocial Questionnaire

SD, Standard Deviation

STCS, Swiss Transplant Cohort Study

US, United States

USD, United States Dollar

Accepted Article

This article is protected by copyright. All rights reserved

Accepted Article

Denhaerynck K, Goldfarb-Rumyantzev AS, Sandhu G, Beckmann S, Huynh-Do U, Binet I, De Geest S. Pre-transplant Social Adaptability Index and clinical outcomes in renal transplantation – The Swiss Transplant Cohort Study. Clin Transplant.

Abstract

BACKGROUND: The impact of pre-transplant social determinants of health on post-transplant outcomes remains understudied. In the US, poor clinical outcomes are associated with underprivileged status, as assessed by the Social Adaptability Index (SAI), a composite score of education, employment status, marital status, household income, and substance abuse. Using data from the Swiss Transplant Cohort Study (STCS), we determined the SAI's predictive value regarding two post-transplant outcomes: all-cause mortality and return to dialysis.

METHODS: Between 2012 and 2018, we included adult renal transplant patients (aged ≥18 years) with pre-transplant assessment SAI scores, calculated from a STCS Psychosocial Questionnaire. Time to all-cause mortality and return to dialysis were predicted using Cox regression.

RESULTS: Of 1238 included patients (mean age: 53.8±13.2 years; 37.9% female; median follow-up time: 4.4 years (IQR: 2.7)), 93 (7.5%) died and 57 (4.6%) returned to dialysis. The SAI's hazard ratio was 0.94 (95%CI: 0.88-1.01; p=0.09) for mortality and 0.93 (95%CI: 0.85-1.02; p=0.15) for return to dialysis.

CONCLUSIONS: In contrast to most published studies on social deprivation, analysis of this Swiss sample detected no significant association between SAI score and mortality or return to dialysis.

Keywords: kidney transplantation, socioeconomic factors, mortality, graft survival

Requests for offprints: Sabina De Geest; Institute of Nursing Science, Department Public Health, University of Basel, Bernoullistrasse 28, CH-4056 Basel; Email: sabina.degeest@unibas.ch

Introduction

Health outcomes result from multilevel, overlapping systems that encompass characteristics not only of individual patients and their social environments, but also of the broader socioeconomic systems within which they reside.[1] Social determinants of health are "the circumstances in which

This article is protected by copyright. All rights reserved

people are born, grow, live, work, and age, and the systems put in place to deal with illness."[2] However, as reported in various healthcare contexts and populations,[2] including organ transplantation,[3-5] differences in those circumstances lead to health disparities, elevating the risks for unfavourable outcomes among socially and/or economically disadvantaged people.[6] Therefore, it may be useful to have pre-transplant indicators that include not only biomedical, but also psychosocial and behavioural risk factors of favourable long-term outcomes. To this end, a comprehensive pre-transplant evaluation has been endorsed by several transplant organizations.[7-10] To support clinicians' pre-transplant evaluations, efforts have also been invested in pre-transplant evaluation instruments.[11-13] In this context, studies of pre-transplant psychosocial and behavioural risk factors or scoring systems are highly relevant, as their findings can increase the rigor of pre-transplant evaluation, which currently includes few pre-transplant social determinants of health.[11-13]

The Social Adaptability Index (SAI), is a US-developed measure of an individual's socio-economic position. It uses a set of risk factors known to influence health outcomes (i.e., educational level, employment status, marital status, household income and substance abuse) to assess the degree to which a patient is (under)privileged.[14-21] A higher SAI score indicates higher social adaptability and has been associated with or shown predictive of better clinical outcomes in both non-transplant[15-17,19,21] and transplant populations—the latter group in terms of graft loss rates,[14,20] mortality,[14] rejection episodes,[20] waiting list times and chances of receiving a transplant.[18] While current evidence suggests that the SAI is predictive of clinical outcomes in the US, its value elsewhere requires substantiation. The implications of being underprivileged may vary between countries depending on their social and healthcare systems. Still, regardless of their location, socially underprivileged persons typically exhibit poorer health behaviour, have less favourable psychosocial profiles and show sub-optimal relationships with their healthcare systems.[6] Representative sampling of the general Swiss population shows associations between socio-economic deprivation and health outcomes such as amenable mortality,[22] breast cancer mortality,[23] systemic inflammation,[24] obesity,[25] frailty,[26] sleep disturbances,[27] lower psychological well-being,[28] and self-reported health,[29,30] mainly attributable to individually measured variables including educational level, income or professional status. Equivalent aggregated (geographically-based) assessments using the same variables show similar results, i.e., higher all-cause mortality, cancers, respiratory and cardiovascular diseases and lower life expectancy, in deprived areas.[31,32]

Despite consensus that transplantation is a chronic health condition that leads to vulnerable long-term health,[33] Switzerland's solid organ transplant recipients have been largely neglected—

This article is protected by copyright. All rights reserved

certainly in contrast to the general Swiss population—regarding social deprivation and its links with health outcomes. For instance, educational level and household income have been studied as risk factors for, respectively, sleep quality[34] and new-onset obesity.[35] Other studies have named pre-transplant employment status as a predictor of better post-transplant health (with health levels assumed based on post-transplant employment status);[36-38] however, prospective, reliably measured indicators of care deprivation—essential tools to identify the full impact of socioeconomic status on general and transplant-specific long-term health outcomes—are lacking.[33] The measurements of the Swiss Transplant Cohort Study (STCS),[39,40] a nation-wide open cohort study, cover the SAI's variables, along with subsequently assessed outcomes. The current study's main aim was to evaluate whether the SAI predicts post-transplant outcomes *all-cause mortality* and *return to dialysis* up to 7 years post-transplant in adult renal transplant patients.

Materials and methods

Design and sample

From the STCS databank on transplant recipients transplanted in Switzerland's 6 transplant centres, we included all single-graft kidney recipients at least 18 years of age whose files included pre-transplant Psychosocial Questionnaire (PSQ) assessments, and who were recruited between January 2012 and January 2018. Switzerland has a comprehensive health and social security system whereby health insurance is compulsory for all residents. Access to care, including transplantation, is guaranteed. Monthly health insurance premiums average approximately 400 USD per adult, plus co-payments for medication and outpatient care. The government subsidizes persons who cannot afford the cost of premiums. Health indicators for Switzerland are among the best worldwide.[41]

Variables and measurements

Socio-demographic, psychosocial, and behavioural variables were collected pre-transplant (at time of wait-listing) via the PSQ, which employs established instruments and items derived from large population studies (e.g., the Swiss Health Survey, the Swiss HIV cohort study). Comprehensive details of the STCS' design and methods are published elsewhere.[39,40] All-cause mortality and return to dialysis were collected until December 2019.

This article is protected by copyright. All rights reserved

Social Adaptability Index. As noted above, the SAI is a composite score of five variables: employment status, education level, marital status, substance use (illicit drug use, smoking, alcohol) and household income. After abstracting corresponding PSQ pre-transplant data,[39,40,42] we optimized their fit to the original SAI by weighting each factor according to the original SAI scoring. This was necessary for *marital status* and *substance use* data, as the STCS' PSQ includes neither a 'married with children' category nor an assessment of alcohol use. We used the following scoring: *Employment status*: 0 = unemployed or not working due to medical conditions; 1 = retired; 2 = part-time work/ housewife/man; 3 = full-time work/ education; *Education level*: 0 = mandatory school or less (max. 9 years); 1 = high school graduate/ equivalent; 2 = some college; 3 = college graduate. *Marital status*: 0 = single (i.e., widowed or never married); 1 = divorced or separated; 2 = married or living together; *Substance abuse*: 0 = smoking or illicit drug use within the past year; 1 = either behaviour; 2 = neither behaviour (*Smoking* was assessed by one item from the Swiss HIV Cohort Study,[43] categorized as current, past (stopped < 1y ago), past (stopped > 1y ago), or never. *Household income*: 0 = under 4500 CHF/month, 1 = 4500-6000 CHF/month; 2 = 6001-9000 CHF/month; 3 = over 9000CHF/month. These categories reflect basic living standards in Switzerland.[44]

To enhance inter-study comparability, we scaled the total SAI score (0 – 13, i.e., the sum of the 5 variable scores) to a maximum of 14. A higher score indicates a more favourable social adaptability. The SAI's known-groups validity has been established in the general population, as it distinguishes between groups known to be subject to health disparities.[15] More specifically, it distinguishes regarding gender (higher scores: males), race (higher scores: Caucasian); and geographic location (higher scores: urban) in the general population.

Statistical analysis

Depending on measurement levels and distribution of variables, descriptive statistics, i.e., frequencies, proportions, measures of central tendency (mean, median), measures of dispersion (standard deviation [SD], and interquartile range [IQR]) were calculated as appropriate. To evaluate whether the SAI predicted all-cause mortality and return to dialysis, we performed survival analyses using Cox regression.[45] Analyses were performed in SAS 9.4 (SAS Institute Inc., Cary, NC, USA). Statistical significance was set at $p<0.05$.

This article is protected by copyright. All rights reserved

Ethical considerations

The STCS was approved by the independent ethics committees of each Swiss transplant centre (EKBB 351/07, KEK 270/07, EKSG 07/122, EK 1487, CER 07-301 [NAC 07-117], Lausanne 284/07). Patients were asked for written informed consent before enrolment. This study was executed in accordance with the ethical principles laid down in the Declaration of Helsinki.

Results

Sample. Of all eligible kidney transplant recipients (n=1446), 91.3% provided informed consent (n=1320), and 1238 (85.6%) had baseline data available. Recipients were on average 53.8 years old (SD 13.2) at the time of transplantation; 37.9% were female (Table 1). The majority of grafts (59.2%) were from deceased donors; 127 recipients had been re-transplanted (13.9%). The median post-transplant follow-up time was 4.4 years (IQR 2.7; range 0.0-7.4). During that period, 93 recipients died (7.5%) and 57 returned to dialysis (4.6%).

Social Adaptability Index. The mean pre-transplant SAI score at transplantation listing was 7.7 (SD 2.9). Regarding the 5 constituent factors, 59.8% of the sample worked part-time or more (or were homemakers); 64.3% were at least high school graduates or equivalent; the majority were married or cohabiting (66.2%); 27.9% reported smoking and/or using illicit drugs; and nearly half (48.7%) had household incomes in the lowest category (i.e., <4500 CHF/month). Exploring associations between patient characteristics and the SAI revealed slightly higher SAI values for recipients who were older, male, Caucasian, had CMV, fewer comorbidities, and shorter dialysis and waiting times. The strongest relationship (R^2=11.6%) was found with graft type: SAI scores were highest for living-unrelated donation (9.4±2.5), followed by living-related donation (8.3±3.0) and deceased donation (7.0±2.6).

Outcome prediction. The hazard ratio of pre-transplant SAI predicting all-cause mortality was 0.94 (95%CI: 0.88-1.01; p=0.085; Table 2) and of return to dialysis 0.93 (95%CI: 0.85-1.02; p=0.148). Analysing SAI subfactors' hazard ratios for both outcomes (Table 2) showed that level of employment predicted mortality; however, the relationship was nonlinear, in that only the category of retired subjects (score=1) was responsible for this lower life expectancy. Controlling for age explained the association between retirement and mortality, suggesting that age, acting as a confounding variable, was the real predictor of mortality for this variable.

This article is protected by copyright. All rights reserved

Accepted Article

Discussion

This prospective study did not demonstrate that the SAI, a measure of (under)privileged status, predicted the post-transplant outcomes of all-cause mortality or return to dialysis in Swiss renal transplant recipients. Compared to most previous research, our hazard ratios indicated lower-end effect sizes[46] (Table 3).[14-21] The SAI has been inversely associated with patient mortality in the general population (as part of NHANES III),[15] chronic kidney disease patients,[17,19] kidney transplant recipients,[14,20] and patients with diabetes.[16] Elsewhere, in patients with end stage renal disease, it has also has also been shown to predict access to wait-listing for renal transplantation and transplantation.[18] In one US sample, the SAI was a strong independent predictor for acute rejection and graft loss but only in African American (vs. non-African American) patients.[20] One study failed to show an association between SAI and depression;[47] another showed nonsignificant results predicting health behavioural and health-related quality of life outcomes in type II diabetics.[21] Our study's exploration of SAI relationships with baseline sample characteristics detected a number of previously-reported associations, such as the association of a higher SAI with shorter waiting times,[18] being of Caucasian descent,[20] having fewer comorbidities,[16,17,19] or having received a living-donor graft compared to one from a deceased donor.[48] While most associations were small (around 1-2% of explained variability), SAI differences were more pronounced between donation types (R^2=12%). Possible explanations are still being investigated.[49]

The SAI has not previously been used in a Western-European context. However, other less granular indices—particularly those assessing social determinants of health in transplantation that are linked to the geographic location of the patient's home[50-52]—found relationships between social deprivation (European Deprivation Index) and survival (but not graft loss) in French kidney transplant recipients,[50] and between mortality and graft loss in English pancreas-kidney transplant recipients (English Index of Multiple Deprivation).[51] Socioeconomically deprived regions in England were also home to more chronic and end-stage kidney disease.[52] In the US as well, neighbourhood social deprivation also correlated with nonadherence to immunosuppressive medications, a determinant of suboptimal long-term outcomes.[53]

Our data were taken from the STCS, a nationwide prospective cohort study including over 95% of patients transplanted in 6 Swiss transplant centers.[39,40] Findings are generalizable for Switzerland, but not necessarily for other countries.[44] Combined with Switzerland's high living standard, its comprehensive health and social insurance system may prevent underprivileged

This article is protected by copyright. All rights reserved

status from acting as an independent risk factor for poor outcomes (e.g., unemployment does not imply losing health insurance). I.e., the small hazard ratios found in this study may be a country-specific effect. On the other hand, in terms of SAI values standardized to a maximum score of 14, our sample's average score of 7.7 positions it solidly in the mid-range of published SAI scores (range: 6.1[47] – 9.2[14]). This may indicate that the SAI lacked the sensitivity to capture existing social deprivation and health inequalities within Switzerland.[54] It needs to be noted that the PSQ's lowest income bracket (<4500 CHF/month; in accordance with Swiss census surveys), is still higher than the official poverty threshold, possibly limiting the income item's sensitivity. In Switzerland, poverty has been associated with incomes under 2293 CHF for a single person and under 3968 CHF for a family with two children.[55]

Another possible reason for our results' divergence from those of previous US research is the difference between American and Swiss socio-economic and regulatory contexts. For instance, access to care, an important driver of outcomes,[56] is never hampered in Switzerland by policies such as restriction of immunosuppressive coverage to the first three years post-transplant.[57] On an individual level, this very likely buffers many of the detrimental health effects of poverty.

Contrary to most global research, paradoxically, Swiss regions with higher income inequality show lower mortality rates.[58] Whether this relates to peculiarities of the Swiss context is unclear. In the US too, geographically-based measures of socio-economic equality have produced associations that depend on the level of aggregation (state vs county),[59] suggesting that hidden causal factors are biasing the apparent associations.[60] Therefore, it would be interesting for future research using STCS data to compare aggregated, geographically-based measures of disparity with their non-aggregated counterparts (e.g., the SAI). This would allow the examination of possible emerging inconsistencies for unknown confounding and/or mediating factors. Also, the possibility remains that with longer follow-up times and a larger STCS sample, the SAI results could become statistically significant; however, this would probably not change the small effect size.

In conclusion, our analysis of data from a sample of Swiss kidney transplant patients resulted in evidence too weak to confirm a link between SAI-measured social deprivation and the clinical outcomes of all-cause mortality and return to dialysis.

This article is protected by copyright. All rights reserved

Acknowledgments

We thank the transplant patients who participated in the STCS and the STCS staff, who contributed daily to the study's data collection and management. We also thank Chris Shultis for editing this paper.

Authors' specific contributions to the study: SDG, ASGR, GS, and KD participated in research design; SDG, ASGR, GS, SB, UHD, IB, KD & members or the STCS Psychosocial Interest Group participated in writing the paper; SDG & KD, the Psychosocial Interest Group & STCS participated in performance of the research; KD & SDG participated in data analysis.

References

1. Centers for Disease Control and Prevention. Social Determinants of Health. https://www.cdc.gov/nchhstp/socialdeterminants/index.html. Accessed May 18, 2020.
2. Marmot M, Friel S, Bell R, Houweling TA, Taylor S, Commission on Social Determinants of H. Closing the gap in a generation: health equity through action on the social determinants of health. Lancet 2008;372:1661-1669.
3. Patzer RE, Perryman JP, Schrager JD, et al. The role of race and poverty on steps to kidney transplantation in the Southeastern United States. Am J Transplant 2012;12:358-368.
4. Tjaden LA, Noordzij M, van Stralen KJ, et al. Racial Disparities in Access to and Outcomes of Kidney Transplantation in Children, Adolescents, and Young Adults: Results From the ESPN/ERA-EDTA (European Society of Pediatric Nephrology/European Renal Association-European Dialysis and Transplant Association) Registry. Am J Kidney Dis 2016;67:293-301.
5. Monson RS, Kemerley P, Walczak D, Benedetti E, Oberholzer J, Danielson KK. Disparities in completion rates of the medical prerenal transplant evaluation by race or ethnicity and gender. Transplantation 2015;99:236-242.
6. Havranek EP, Mujahid MS, Barr DA, et al. Social Determinants of Risk and Outcomes for Cardiovascular Disease: A Scientific Statement From the American Heart Association. Circulation 2015;132:873-898.

This article is protected by copyright. All rights reserved

Accepted Article

7. Mehra MR, Kobashigawa J, Starling R, et al. Listing criteria for heart transplantation: International Society for Heart and Lung Transplantation guidelines for the care of cardiac transplant candidates--2006. J Heart Lung Transplant 2006;25:1024-1042.
8. Pascual J, Abramowicz D, Cochat P, et al. European renal best practice guideline on the management and evaluation of the kidney donor and recipient. Nefrologia 2014;34:293-301.
9. UNOS. General Considerations in Assessment for Transplant Candidacy. https://optnpilot.unos.org/resources/ethics/general-considerations-in-assessment-for-transplant-candidacy/. Accessed 18 May, 2020.
10. Dew MA, DiMartini AF, Dobbels F, et al. The 2018 ISHLT/APM/AST/ICCAC/STSW recommendations for the psychosocial evaluation of adult cardiothoracic transplant candidates and candidates for long-term mechanical circulatory support. J Heart Lung Transplant 2018;37:803-823.
11. Presberg BA, Levenson JL, Olbrisch ME, Best AM. Rating scales for the psychosocial evaluation of organ transplant candidates. Comparison of the PACT and TERS with bone marrow transplant patients. Psychosomatics 1995;36:458-461.
12. Twillman RK, Manetto C, Wellisch DK, Wolcott DL. The Transplant Evaluation Rating Scale. A revision of the psychosocial levels system for evaluating organ transplant candidates. Psychosomatics 1993;34:144-153.
13. Maldonado JR, Sher Y, Lolak S, et al. The Stanford Integrated Psychosocial Assessment for Transplantation: A Prospective Study of Medical and Psychosocial Outcomes. Psychosom Med 2015;77:1018-1030.
14. Garg J, Karim M, Tang H, et al. Social adaptability index predicts kidney transplant outcome: a single-center retrospective analysis. Nephrol Dial Transplant 2012;27:1239-1245.
15. Goldfarb-Rumyantzev A, Barenbaum A, Rodrigue J, Rout P, Isaacs R, Mukamal K. New social adaptability index predicts overall mortality. Arch Med Sci 2011;7:720-727.
16. Goldfarb-Rumyantzev AS, Rout P, Sandhu GS, et al. Social adaptability index predicts overall mortality in patients with diabetes. J Diabetes Complications 2012;26:44-49.
17. Goldfarb-Rumyantzev AS, Rout P, Sandhu GS, Khattak M, Tang H, Barenbaum A. Association between social adaptability index and survival of patients with chronic kidney disease. Nephrol Dial Transplant 2010;25:3672-3681.
18. Goldfarb-Rumyantzev AS, Sandhu GS, Baird BC, Khattak M, Barenbaum A, Hanto DW. Social Adaptability Index predicts access to kidney transplantation. Clin Transplant 2011;25:834-842.

This article is protected by copyright. All rights reserved

19. Sandhu GS, Khattak M, Rout P, et al. Social Adaptability Index: application and outcomes in a dialysis population. Nephrol Dial Transplant 2011;26:2667-2674.
20. Taber DJ, Hamedi M, Rodrigue JR, et al. Quantifying the Race Stratified Impact of Socioeconomics on Graft Outcomes in Kidney Transplant Recipients. Transplantation 2016;100:1550-1557.
21. Campbell JA, Walker RJ, Smalls BL, Egede LE. Use of social adaptability index to explain self-care and diabetes outcomes. BMC Endocr Disord 2017;17:34.
22. Feller A, Schmidlin K, Clough-Gorr KM. Trends and socioeconomic inequalities in amenable mortality in Switzerland with international comparisons. Swiss Med Wkly 2017;147:w14478.
23. Feller A, Schmidlin K, Bordoni A, et al. Socioeconomic and demographic disparities in breast cancer stage at presentation and survival: A Swiss population-based study. Int J Cancer 2017;141:1529-1539.
24. Fraga S, Marques-Vidal P, Vollenweider P, et al. Association of socioeconomic status with inflammatory markers: a two cohort comparison. Prev Med 2015;71:12-19.
25. de Mestral C, Chatelan A, Marques-Vidal P, Stringhini S, Bochud M. The Contribution of Diet Quality to Socioeconomic Inequalities in Obesity: A Population-based Study of Swiss Adults. Nutrients 2019;11.
26. Guessous I, Luthi JC, Bowling CB, et al. Prevalence of frailty indicators and association with socioeconomic status in middle-aged and older adults in a swiss region with universal health insurance coverage: a population-based cross-sectional study. J Aging Res 2014;2014:198603.
27. Stringhini S, Haba-Rubio J, Marques-Vidal P, et al. Association of socioeconomic status with sleep disturbances in the Swiss population-based CoLaus study. Sleep Med 2015;16:469-476.
28. Vetter S, Endrass J, Schweizer I, Teng HM, Rossler W, Gallo WT. The effects of economic deprivation on psychological well-being among the working population of Switzerland. BMC Public Health 2006;6:223.
29. Bauer GF, Huber CA, Jenny GJ, Muller F, Hammig O. Socioeconomic status, working conditions and self-rated health in Switzerland: explaining the gradient in men and women. Int J Public Health 2009;54:23-30.
30. Hammig O, Gutzwiller F, Kawachi I. The contribution of lifestyle and work factors to social inequalities in self-rated health among the employed population in Switzerland. Soc Sci Med 2014;121:74-84.

Accepted Article

This article is protected by copyright. All rights reserved

Accepted Article

31. Moser A, Panczak R, Zwahlen M, et al. What does your neighbourhood say about you? A study of life expectancy in 1.3 million Swiss neighbourhoods. J Epidemiol Community Health 2014;68:1125-1132.
32. Panczak R, Galobardes B, Voorpostel M, et al. A Swiss neighbourhood index of socioeconomic position: development and association with mortality. J Epidemiol Community Health 2012;66:1129-1136.
33. Gruttadauria S, Grosso G, Mistretta A, et al. Impact of recipients' socio-economic status on patient and graft survival after liver transplantation: the IsMeTT experience. Dig Liver Dis 2011;43:893-898.
34. Burkhalter H, Denhaerynck K, Huynh-Do U, et al. Change of sleep quality from pre- to 3 years post-solid organ transplantation: The Swiss Transplant Cohort Study. PLoS One 2017;12:e0185036.
35. Beckmann S, Denhaerynck K, Stampf S, et al. New-onset obesity after liver transplantation-outcomes and risk factors: the Swiss Transplant Cohort Study. Transpl Int 2018;31:1254-1267.
36. Eppenberger L, Hirt-Minkowski P, Dickenmann M. Back to work? Socioeconomic status after kidney transplantation. Swiss Med Wkly 2015;145:w14169.
37. Danuser B, Simcox A, Studer R, Koller M, Wild P, Psychosocial Interest Group STCS. Employment 12 months after kidney transplantation: An in-depth bio-psycho-social analysis of the Swiss Transplant Cohort. PLoS One 2017;12:e0175161.
38. Vieux L, Simcox AA, Mediouni Z, et al. Predictors of Return to Work 12 Months After Solid Organ Transplantation: Results from the Swiss Transplant Cohort Study. J Occup Rehabil 2019;29:462-471.
39. De Geest S, Burkhalter H, Berben L, et al. The Swiss Transplant Cohort Study's framework for assessing lifelong psychosocial factors in solid-organ transplants. Prog Transplant 2013;23:235-246.
40. Koller MT, van Delden C, Muller NJ, et al. Design and methodology of the Swiss Transplant Cohort Study (STCS): a comprehensive prospective nationwide long-term follow-up cohort. Eur J Epidemiol 2013;28:347-355.
41. Biller-Andorno N, Zeltner T. Individual Responsibility and Community Solidarity--The Swiss Health Care System. N Engl J Med 2015;373:2193-2197.
42. De Geest S, Burkhalter H, Bogert L, et al. Describing the evolution of medication nonadherence from pretransplant until 3 years post-transplant and determining pretransplant medication nonadherence as risk factor for post-transplant nonadherence to immunosuppressives: The Swiss Transplant Cohort Study. Transpl Int 2014;27:657–666.

This article is protected by copyright. All rights reserved

43. Schoeni-Affolter F, Ledergerber B, Rickenbach M, et al. Cohort profile: the Swiss HIV Cohort study. Int J Epidemiol 2010;39:1179-1189.
44. Swiss Federal Statistical Office. Household income and expenditure. https://www.bfs.admin.ch/bfs/en/home/statistics/economic-social-situation-population/income-consumption-wealth/household-budget.html. Accessed May 18, 2020.
45. Cox D. Regression models and life tables. J R Stat Soc 1972;B34:187-220.
46. Azuero A. A note on the magnitude of hazard ratios. Cancer 2016;122:1298-1299.
47. Santos PR, Arcanjo FP. Social adaptability and substance abuse: predictors of depression among hemodialysis patients? BMC Nephrol 2013;14:12.
48. Bailey P, Tomson C, Risdale S, Ben-Shlomo Y. From potential donor to actual donation: does socioeconomic position affect living kidney donation? A systematic review of the evidence. Transplantation 2014;98:918-926.
49. Bailey PK, Tomson CR, Ben-Shlomo Y. What factors explain the association between socioeconomic deprivation and reduced likelihood of live-donor kidney transplantation? A questionnaire-based pilot case-control study. BMJ Open 2016;6:e012132.
50. Chatelet V, Bayat-Makoei S, Vigneau C, Launoy G, Lobbedez T. Renal transplantation outcome and social deprivation in the French healthcare system: a cohort study using the European Deprivation Index. Transpl Int 2018;31:1089-1098.
51. Asderakis A, Khalid U, Madden S, Dayan C. The influence of socioeconomic deprivation on outcomes in pancreas transplantation in England: Registry data analysis. Am J Transplant 2018;18:1380-1387.
52. Weldegiorgis M, de Zeeuw D, Heerspink HJ. Renal end points in clinical trials of kidney disease. Curr Opin Nephrol Hypertens 2015;24:284-289.
53. Wadhwani SI, Bucuvalas JC, Brokamp C, et al. Association Between Neighborhood-level Socioeconomic Deprivation and the Medication Level Variability Index for Children Following Liver Transplantation. Transplantation 2020.
54. Swiss Federal Statistical Office. Poverty and Material deprivation. https://www.bfs.admin.ch/bfs/en/home/statistics/economic-social-situation-population/economic-and-social-situation-of-the-population/poverty-and-material-deprivation/material-deprivation.html. Accessed May 18, 2020.
55. Swiss Federal Statistical Office. Poverty. https://www.bfs.admin.ch/bfs/en/home/statistics/economic-social-situation-population/economic-and-social-situation-of-the-population/poverty-and-material-deprivation/poverty.html, June 18, 2020.

Accepted Article

This article is protected by copyright. All rights reserved

56. Schold JD, Heaphy EL, Buccini LD, et al. Prominent impact of community risk factors on kidney transplant candidate processes and outcomes. Am J Transplant 2013;13:2374-2383.
57. Gill JS, Tonelli M. Penny wise, pound foolish? Coverage limits on immunosuppression after kidney transplantation. N Engl J Med 2012;366:586-589.
58. Clough-Gorr KM, Egger M, Spoerri A. A Swiss paradox? Higher income inequality of municipalities is associated with lower mortality in Switzerland. Eur J Epidemiol 2015;30:627-636.
59. Cohen SA, Greaney ML, Klassen AC. A "Swiss paradox" in the United States? Level of spatial aggregation changes the association between income inequality and morbidity for older Americans. Int J Health Geogr 2019;18:28.
60. Pearl J. Comment: Understanding Simpson's Paradox. Am Stat 2014;68:8-13.

Accepted Article

This article is protected by copyright. All rights reserved

Accepted Article

Table 1: Sample characteristics (n=1238)

Variable	Measure	Values	SAI higher if…
Demographic and clinical variables			
Age at transplantation in years	Mean ± SD; min-max	53.8±13.2; 18-82	Older (p=.0008; R^2=0.9%)
Gender	N (%) females	469 (37.9%)	Male (p<.0001; R^2=1.5%)
Ethnicity	N (%) Caucasian	1108 (92.0%)	Caucasian (p=.0002; R^2=1.1%)
Cytomegalovirus (CMV)	N (%) Yes	779 (63.4%)	CMV (p<.0001; R^2=1.9%)
Co-morbidity categories	N (%) Cancer (except for skin cancer)	141 (14.4%)	Cancer (p=0.51; R^2=0.04%)
	N (%) Skin cancer	75 (6.6%)	Skin cancer (p=0.08; R^2=0.3%)
	N (%) Cardio-pulmonary diseases (coronary heart disease, peripheral & cerebral vascular diseases, left ventricular dysfunction, pulmonary embolism or venous thrombosis)	613 (54.2%)	No Cardio-pulmonary disease (p<.0001; R^2=1.8%)
	N (%) Metabolic, endocrine diseases (diabetes, hyperlipidemia, hypertension)	1022 (91.2%)	Metabolic disease (p=0.31; R^2=0.09%)
	N (%) Other events/diseases (e.g., nontransplant surgery, bone fractures, infections, …)	565 (51.1%)	Other event/disease (p=0.01; R^2=0.6%)
	Number of co-morbidity categories: Mean ± SD	2.0±1.1	Less comorbidities (p=0.03; R^2=0.4%)
	Median; IQR; min-max	2; 2; 0-5	
Time on dialysis (n=816) (in years)	Mean ± SD	3.3±2.9	Shorter dialysis time (p<.0001; R^2=2.5%)
	Median; IQR; min-max	3; 3; 0.0-26	
Time on waiting list (in years)	Mean ± SD	1.6±1.8	Shorter time waiting (p<.0001; R^2=1.7%)
	Median; IQR; min-max	0.8; 2.9; 0.0-12.6	
Follow up time (in years)	Mean ± SD	4.4±1.7	/

This article is protected by copyright. All rights reserved

Accepted Article

	Median (IQR; min-max)	4.4 (2.7; 0.0-7.4)	
Transplant-related variables			
Graft type	N (%) Living-related donor	237 (19.1%)	Livin-unrelated > -related >
	N (%) Living-unrelated donor	268 (21.7%)	deceased donation (p=.0001;
	N (%) Deceased donor	733 (59.2%)	R^2=11.6%)
Retransplantation	N (%) Re-transplants	172 (13.9%)	No re-tx (p=0.22; R^2=0.1%)
Social Adaptability Index (SAI) variables (pre-transplant)			
SAI (total score)	Mean ± SD	7.7±2.9	
	Median (IQR; min-max)	7.6; 4.2; 0.0-14.0	
Employment	N (%) Unemployed (medically related or not)	318 (25.7%)	
	N (%) Retired	179 (14.5%)	
	N (%) Part time; housewife/-man	468 (37.9%)	
	N (%) Full time; in education	271 (21.9%)	
Education	N (%) Mandatory school or less (max. 9 years)	463 (35.8%)	
	N (%) High school graduate or equivalent	477 (39.2%)	
	N (%) Some college	186 (15.3%)	
	N (%) College graduate	119 (9.8%)	
Marital status	N (%) Single	261 (21.2%)	
	N (%) Divorced/separated	156 (12.7%)	
	N (%) Married/living together	816 (66.2%)	
Substance use	N (%) Illicit drug use and tobacco	31 (2.5%)	
	N (%) Illicit drug use or tobacco	314 (25.4%)	
	N (%) None of the above	890 (72.1%)	
Household income [a]	N (%) < 4500 CHF	493 (48.7%)	
	N (%) 4500-6000 CHF	263 (26.0%)	

This article is protected by copyright. All rights reserved

	N (%) 6001-9000 CHF	143 (14.1%)
	N (%) > 9000 CHF	113 (11.2%)
Outcome variables (post-transplant)		
All-cause mortality	N (%) of deceased patients	93 (7.5%)
Return to dialysis	N (%) of graft losses	57 (4.6%)

[a] 1 CHF = 0.93€, 1CHF = 1.09 US$; Conversion rates on October 7, 2020; http://www.xe.com/

Accepted Article

This article is protected by copyright. All rights reserved

Table 2: Pre-transplant SAI total and sub-scores as predictors (n=1238)

Variable	Unadjusted Hazard Ratio (95% Confidence Interval)	p-value
SAI total score predicting *all cause mortality*		
All cause mortality	0.94 (0.88-1.01)	0.085
SAI total score predicting *return to dialysis*		
Return to dialysis	0.93 (0.85-1.02)	0.148
SAI-components: 5 separate models predicting *all cause mortality*		
Employment	0.75 (0.62-0.90)	0.002
Education	1.04 (0.84-1.29)	0.717
Household income	0.87 (0.70-1.09)	0.238
Marital status	0.98 (0.83-1.16)	0.821
Substance use	0.88 (0.69-1.13)	0.328
SAI-components: 5 separate models predicting *return to dialysis*		
Employment	0.87 (0.69-1.10)	0.258
Education	0.76 (0.56-1.04)	0.085
Household income	0.90 (0.67-1.20)	0.459
Marital status	0.95 (0.77-1.17)	0.620
Substance use	0.97 (0.70-1.36)	0.875

Accepted Article

This article is protected by copyright. All rights reserved

Accepted Article

Table 3: Overview of studies using the SAI

Study	Population	Mean ± standard deviation	Outcome	Hazards ratio / Means ± standard deviation / R^2 & p-values	Cohen's d
This study	Kidney transplants (CH)	7.7±2.6	Mortality	HR 0.94 (0.88 – 1.01), p=0.085	-0.037 (-0.077 – 0.006)
			Graft loss	HR 0.93 (0.85 – 1.02), p=0.148	-0.032 (-0.071 – 0.009)
Goldfarb et al. 2011[18]	Kidney transplants (US)	7.1±2.5	Wait listed	HR 1.19 (1.15 – 1.23), p < .001	0.104 (0.084 – 0.124)
			Receiving transplant	HR 1.06 (1.03 – 1.09), p < .001	0.035 (0.018 – 0.052)
Goldfarb et al. 2010[17]	ESRD (US)	7.3±2.7	Mortality	HR 0.88 (0.86 – 0.89), p < .001	-0.077 (-0.091 – -0.070)
Sandhu et al. 2011[19]	Dialysis (US)	7.1±2.5	Mortality	HR 0.97 (0.95 – 0.99), p = .006	-0.018 (-0.031 – -0.006)
Goldfarb et al. 2011[15]	General population (US)	8.3	Mortality	HR 0.87 (0.84 – 0.90), p < .001	-0.084 (-0.105 – -0.063)
Goldfarb et al. 2012[16]	Diabetes (US)	6.6±2.4	Mortality	HR 0.90, p < .001	-0.063
Garg et al. 2012[14]	Kidney transplants (US)	9.2±2.5	Graft loss	HR 0.89, p < .05	-0.070
			Mortality	HR 0.84, p < .01	-0.105
Santos 2013[30]	Depressed patients (Brazil)	6.1±1.8	Being depressed	6.1±1.6 vs. 6.2±1.9, p=0.901	-0.05 (-0.31 – 0.41)
Taber 2016[20]	Kidney transplants (US)		Acute rejection		
	-African Americans	6.5	-African Americans	HR 0.89 (0.80 – 0.99), p < .027	-0.070 (-0.134 – -0.006)
	-Non-African Americans	7.8	-Non-African Americans	HR 0.92 (0.81 – 1.05), p < .215	-0.050 (-0.127 – 0.029)
			Graft loss		
			-African Americans	HR 0.23 (0.06 – 0.93), p < .039	-0.882 (-0.689 – -0.044)
			-Non-African Americans	HR 1.01 (0.28 – 3.62), p < .993	0.006 (-0.764 – 0.772)
Campbell 2017[21]	Diabetes patients (US)		General diet	R^2=0.0016, NS	0.003
			Specific diet	R^2=0.0063, NS	0.01
			Exercise	R^2=0.0004, NS	0.001

This article is protected by copyright. All rights reserved

	Blood sugar	R^2=0.0008, NS	-0.001
	Foot care	R^2=0.0013, NS	-0.002
	A1c	R^2=0.0008, NS	-0.002
	Blood pressure	R^2=0.0015, NS	0.003
	Lipids	R^2=0.0001, NS	-0.0002
	Health-related quality of life		
	- Physical component	R^2=0.0002, NS	0.0004
	- Mental component	R^2=0.23, p<.001	0.67

Accepted Article

This article is protected by copyright. All rights reserved