Co-occurrence of chronic disease lifestyle risk factors in middle-aged and older immigrants: A cross-sectional analysis of 264,102 Australians

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A B S T R A C T

Background. The way in which lifestyle risk factors for chronic disease co-occur among people with different cultural backgrounds is largely unknown.

Methods. This study investigated chronic disease risk among immigrants aged ≥45 years in Australia by combining common lifestyle risk factors into a weighted chronic disease risk index (CDRI). Among 64,194 immigrants and 199,908 Australian-born participants in the 45 and Up Study (2006–2009), Poisson regression was used to derive relative risks (RR) and 95% confidence intervals (CI) for five risk factors (smoking, alcohol use, overweight/obesity, physical activity, diet) by place of birth adjusting for socio-demographic characteristics. Multiple linear regression was used to determine adjusted mean differences (AMDs) in CDRI score by place of birth and years lived in Australia.

Results. Immigrants had higher RRs of smoking than Australian-born participants, lower RRs of excessive alcohol consumption and overweight/obesity, and no difference in RR for physical inactivity and insufficient fruit/vegetable intake. Participants born in the Middle East/North Africa (AMD 3.5, 95% CI 2.7, 4.3), Eastern/Central Europe (1.3, 0.8, 1.9), and Western Europe (0.5, 0.1, 0.8) had higher mean CDRI scores than Australian-born participants, while participants born in East Asia (−7.2, −7.8, −6.6), Southeast Asia (−6.6, −7.2, −6.1), Central/South Asia (−3.1, −4.0, −2.1), Sub-Saharan Africa (−1.9, −2.6, −1.2) and the United Kingdom/Ireland (−0.2, −0.5, 0.0) had lower scores. CDRI score among immigrants generally approximated that of Australian-born participants with greater years lived in Australia.

Conclusions. This study reveals differences in potential risk of chronic disease among different immigrant groups in Australia.

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Introduction

Non-communicable diseases have a major impact on premature morbidity and mortality, comprising around 55% of the burden of disease globally, and 85% in Australia (2010) (Murray et al., 2012a). A large proportion of the burden comes from chronic diseases that share many lifestyle risk factors including smoking, alcohol intake, physical inactivity and poor diet (Australian Institute of Health and Welfare, 2014).

While the population prevalence of individual lifestyle risk factors is routinely ascertainment through national health surveys, it is important to consider that these risk factors do not often occur in isolation. Indeed, risk factors often cluster and can interact, where the risk of chronic disease may be elevated above that of the sum of each risk factor considered individually (Australian Institute of Health and Welfare, 2005, 2012). Lifestyle risk factor co-occurrence has also been shown to influence mortality, whereby mortality risk is proportionate to the number of healthy lifestyle behaviours adhered to (Lofef and Walach, 2012). To better estimate chronic disease risk it is therefore necessary to study lifestyle risk factors in combination.

Risk factor prevalence and the burden of chronic disease vary greatly across different regions of the world (Murray et al., 2012a; World Health Organisation, 2014). For example, in 2007–2010, 36% of the Chinese population aged ≥50 years were found to have three or more chronic disease risk factors, compared to 45% for India, 56% for Russia and 69% for South Africa (Wu et al., 2015). In Australia (2007–2008), it was found that 64% of adults had at least three chronic disease risk factors, with males, those aged ≥75 years, those with disadvantaged socio-economic status, and those living in rural areas having the greatest proportion (Australian Institute of Health and Welfare, 2012). However, the way in which chronic disease risk factors co-occur among people...
with different cultural backgrounds in Australia is largely unknown. Of twelve studies included in a systematic review of cardiovascular disease risk factors among immigrant groups in Australia, only one considered multiple risk factors together (Dassanayake et al., 2009). The Australian population has a relatively high proportion of immigrants (27% in 2011) and ethnic diversity (60% of immigrants originate from non-European countries and 53% speak a language other than English at home) (Australian Bureau of Statistics, 2012). Further, chronic disease incidence (Dassanayake et al., 2009; Hodge et al., 2004; Supramaniam et al., 2006) and mortality (Anikeeva et al., 2011, 2015), as well as individual risk factors (Centre for Epidemiology and Research, 2010; Singh and de Looper, 2002; Bennett, 1993) have been found to vary substantially in Australia by place of birth. For example, from 1981–2007, death from lung, stomach, and bladder cancer was more common among immigrants than the Australian-born population, whereas immigrants were less likely to die from colorectal cancer (Anikeeva et al., 2011). Death from cardiovascular disease was higher among immigrants from Eastern Europe (1997–2007), but lower for other parts of Europe, and lowest among Chinese Asians (Anikeeva et al., 2015). In the same period, the immigrant groups with the highest number of deaths from diabetes mellitus were those from Southern Europe, Eastern Europe, and Southern Asia (Anikeeva et al., 2015). Understanding how modifiable health behaviours may contribute to variations in health outcomes can potentially be achieved by exploring multiple risk factors.

There are various methods for quantifying multiple risk factors (McAloney et al., 2013), but it is important to account for the fact that some risk factors have stronger associations with chronic diseases than others. The Chronic Disease Risk Index (CDRI) developed by Miller and Bauman (2005) accounts for the proportional impact of each risk factor on disease using a population health survey in New South Wales (NSW), Australia (Miller and Bauman, 2005). This index takes into account the impact of each factor on loss of disability-adjusted life years in Australia (Miller and Bauman, 2005; Miller, 2003).

We applied this CDRI to self-reported health and lifestyle data from the baseline questionnaire of a large cohort study in NSW, the 45 and Up Study. We aimed to identify immigrant groups with higher or lower CDRI than Australian-born participants, and determine how this relationship varies by number of years lived in Australia.

**Methods**

**Study sample**

Baseline data from the Sax Institute’s 45 and Up Study (2006–2009), a cohort study of 266,848 participants was used. The study is described elsewhere (Banks et al., 2008), but briefly, residents of NSW aged at least 45 years were randomly sampled from the general population using the Medicare Australia database. This database includes records for all citizens and permanent residents of Australia, and also some temporary residents and refugees. Persons aged 80 and over and those living in rural and remote areas were oversampled by a factor of two. The response rate to mailed invitations was estimated to be 18% (Banks et al., 2008). Ethics approval for the study was provided by the University of NSW Human Research Ethics Committee and the Cancer Council NSW Ethics Committee.

**Place of birth and years lived in Australia**

Immigrants were defined as persons who reported a country of birth other than Australia. To ensure adequate sample sizes for comparison, countries of birth were grouped into thirteen regions (see Table A.1 supplementary content). These are modified groups from the Global Burden of Disease Study and have been used previously to analyse 45 and Up Study data (Murray et al., 2012b; Weber et al., 2011). The regions were generated to maximise inter-region variation and minimise intra-region variation in infant mortality and adult morbidity and mortality (Murray et al., 2012b). Participants with missing or invalid places of birth were excluded from the analyses. Number of years lived in Australia was calculated using the survey date and year first lived in Australia for one year or more.

**Chronic disease risk index (CDRI) and lifestyle risk factors**

A CDRI score was calculated for each participant using the methods of Miller and Bauman (Miller and Bauman, 2005; Miller, 2003). Specifically, five self-reported risk factors (smoking, alcohol, BMI, physical activity and fruit and vegetable intake) were assigned values between 0 and 1 to capture the magnitude of associations with disability adjusted life years in Australia. These were then summed to create a CDRI score for each participant, with higher scores indicating greater chronic disease risk. Scores ranged from 0 to 3.8, and were re-scaled into a 100-point scale.

BMI (calculated from self-reported height and weight (Ng et al., 2011)) and physical activity (weekly number of sessions and time in minutes, with time spent in vigorous activity doubled as it was assumed to have twice the metabolic equivalent value of low and moderate activity (Australian Institute of Health and Welfare, 2003; Australian Government Department of Health, 2014)) were assigned risk values as per the original methodology (Miller and Bauman, 2005; Miller, 2003). Smoking status, alcohol and fruit and vegetable intake were modified as described below.

Current smoking was assigned a risk value of 1, former smoking 0.5 and never-smoking 0. We were not able to include a category for occasional smoking (assigned a value of 0.8).

Alcohol consumption was divided into ‘low risk’ (assigned a value of 0), ‘hazardous’ (assigned 0.3), and ‘harmful’ (assigned 0.4) levels. For men this equated to ≤4, >4 and ≤6, and >6 standard drinks per occasion respectively, and for women, ≤2, >2 and ≤4, and >4. We used days of drinking as a substitute for occasions of drinking.

Participants in the low tertile of fruit and vegetable intake (≤3 serves of total fruit/vegetables per day) were assigned a value of 0.4, those in the moderate tertile (≥3 and <5 serves/day) a value of 0.2, and those in the high tertile (≥5 serves/day) a value of 0. Tertile cut-off values were based on the 2010 NSW Population Health Survey (Centre for Epidemiology and Research, 2011).

Participants with incomplete data for any of the five lifestyle risk factors were excluded from CDRI analyses.

**Socio-demographic covariates**

All socio-demographic covariates analysed are listed in Table 1. Remoteness was derived from postcode using the Accessibility/Remoteness Index for Australia (ARIA + 2006) (Glover and Tennant, 2003). A missing indicator variable was included for each factor.

**Statistical analyses**

We examined the distribution of socio-demographic characteristics by place of birth. All subsequent analyses were adjusted for sex, age, remoteness, education level, marital status, household income and health insurance status.

It has been shown that for binary outcomes, exponentiated linear coefficients estimated from Poisson regression provide valid estimates of adjusted relative risk, and robust standard errors produce confidence intervals that achieve nominal coverage (Zou, 2004; Greenland, 2004; Spiegelman and Hertzmark, 2005). This method has been referred to as modified Poisson regression, and was used to calculate the adjusted relative risk (RR) and 95% confidence interval (CI) of being in the highest risk category for each individual risk factor by place of birth. That is, being a current smoker, drinking a harmful level of alcohol, being obese, being physically inactive and being in the lowest tertile of fruit and vegetable intake.

Multiple linear regression was used to determine adjusted mean differences (AMDs) in CDRI score by place of birth and years lived in Australia. In each regression model, place of birth and socio-demographic covariates were the independent variables and CDRI score was the dependent variable. A test for trend between years lived in Australia and CDRI score (using the median value for each category of years lived in Australia: <10; 10–19; 20–29; 30–39; ≥40 years) was used for each region of birth.

Analyses were performed using SAS 9.3.

**Results**

266,848 participants completed the baseline questionnaire. 22 (0.008%) of these were excluded for being <45 years old. A further
Percentages include participants with missing or invalid responses. SD, standard deviation. IQR, interquartile range.

Mean CDRI scores ranged from 14.9 for participants from East Asia to 23.6 for participants from Australia. The contribution of each risk factor to the adjusted mean CDRI score from Australian-born participants are shown in Table 3. After adjusting for covariates, immigrants overall had a significantly higher RR of current smoking and a lower RR of harmful alcohol consumption and obesity than Australian-born participants.

Analyses from this point excluded 43,731 participants (16.4%) with missing or invalid responses for at least one of the five risk factors, leaving 220,371 participants. 17,273 (10.3%) Australian-born and 5659 (10.6%) immigrant participants had the lowest possible CDRI score of 0, while 32 (0.019%) Australian-born and 6 (0.011%) immigrant participants had scores ≥90.

For each region of birth, the mean CDRI score and adjusted mean difference (AMD) in CDRI score from Australian-born participants are shown in Table 3. The contribution of each risk factor to the adjusted mean CDRI score is shown in the supplementary content (Figure A1). Mean CDRI scores ranged from 14.9 for participants from East Asia to 27.7 for participants from the Middle East and North Africa. There was significant variation in CDRI by place of birth (p < 0.0001). Participants born in all Asian regions, the United Kingdom (UK) and Ireland and Sub-Saharan Africa had lower CDRI scores than Australian-born participants. Significantly higher CDRI scores were observed for Western Europe, Eastern and Central Europe and the Middle East and North Africa.

The AMD in CDRI score by 10-year strata of years lived in Australia for each region of birth is shown in Fig. 1. 1949 (0.7%) participants with missing or invalid responses for age of migration were excluded, leaving 218,422 participants for these analyses. For immigrants overall, there was a significant increasing trend in AMD in CDRI score with increasing years lived in Australia (p < 0.001), with those living in Australia ≥10 years having an AMD of −3.4 and those living in Australia ≥40 years having an AMD of 0.6.

A significant increasing trend in AMD was found for participants born in Oceania, all Asian regions, the UK and Ireland and Western Europe, with those living in Australia <10 years having an AMD ranging between −9.5 and −1.9, and those living in Australia ≥40 years having an AMD ranging between −1.3 and 1.1. No significant trends in AMD were found for the remaining regions of birth.

Discussion

We found diversity in the co-occurrence of chronic disease lifestyle risk factors across different immigrant groups in the 45 and Up Study in NSW, Australia. Using the CDRI developed by Miller and Bauman, we found that only about 10% of both Australian-born and immigrant participants overall had the lowest possible risk of chronic disease. Participants born in Western Europe, Eastern and Central Europe, and the Middle East and North Africa had a mean CDRI score that potentially
<table>
<thead>
<tr>
<th>Lifestyle risk factors by place of birth using the maximum risk category for each risk factor in the chronic disease risk index in the 45 and Up Study (2006–2009), New South Wales, Australia.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RRa (95% CI) Harmful alcohol Physical inactivity Low fruit and vegetable intakea (%)</td>
</tr>
<tr>
<td>Place of birth</td>
</tr>
<tr>
<td>Australia</td>
</tr>
<tr>
<td>New Zealand</td>
</tr>
<tr>
<td>East Asia</td>
</tr>
<tr>
<td>Central &amp; South Asia</td>
</tr>
<tr>
<td>Western Europe</td>
</tr>
<tr>
<td>Eastern &amp; Central Europe</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
</tr>
<tr>
<td>Oceania</td>
</tr>
<tr>
<td>Total immigrants</td>
</tr>
</tbody>
</table>

- b N 6 standard drinks per occasion if male; N 4 if female.
- c spies 3 serves of total fruit and vegetables per day.

It is unclear how the health profile of participants in this study may compare to that of their country of origin. Studies comparing multiple risk factors across countries are few. One study that directly compared data from six countries found that multiple risk factors occurred much more frequently in upper-middle income countries than in low-middle income countries (Wu et al., 2015). The authors suggested that lower-middle income countries are less likely to be exposed to risk factors associated with urban living (such as sedentary lifestyles and processed foods). However, immigrants are often a specific sub-group of their country of origin and are not necessarily representative of the population they left behind. Migration policies to Australia are complex, change over time and vary from a selection of skilled migrants using a points system to small groups of refugees accepted on humanitarian grounds (Statistics Section Department of Immigration and Multicultural Affairs, 2001). As such, socioeconomic factors among immigrant groups, such as educational attainment, can be higher than that of their home country (and Australian-born for that matter) (Australian Bureau of Statistics, 2007). Nevertheless, the immigrant groups with the lowest health risks in our study were also from lower-middle income countries (e.g., those included in East and Southeast Asia), which suggests that some of the lifestyle patterns prior to migration may have been maintained.

A pattern of increasing CDRI score with increasing strata of years lived in Australia suggests that lifestyle behaviours may 'acculturate' for some immigrant groups, whereby immigrants tend to adopt the health behaviours of the host population over time (Bennett, 1993; Delavari, 2013). However, this was not observed for all regions of birth, and specifically, those with mean CDRI scores that were higher than Australian-born participants (i.e. immigrants from Eastern/Central Europe and the Middle East/North Africa). These immigrant groups tended to have higher CDRI scores regardless of the number of years lived in Australia. This may indicate that acculturation of health behaviours primarily occurs when immigrants adopt poorer health behaviours over time, but not the opposite. A review of acculturation and obesity appears to support this hypothesis, finding that seven of nine studies reported a positive association between higher acculturation and body weight variables, while three studies reported a negative
association in females only (Delavari et al., 2013). As well as obesity, acculturation has been observed with physical activity and diet (Huang et al., 1996; Shah et al., 2015). For example, in a study of Japanese–American men in Hawaii it was found that those who retained a traditional Japanese diet and had spent more time living in Japan had a lower BMI, higher physical activity levels and a healthier diet, and a reduced prevalence of type 2 diabetes than those who adopted a ‘Westernised’ lifestyle (Huang et al., 1996).

Possible explanations for the differences in risk factor co-occurrence between immigrant groups are the diversity in levels of urbanisation and socioeconomic development in low-, middle- and high-income countries, and the rate of ‘risk transition’ from infectious disease burden to non-communicable diseases burden over time (Wu et al., 2015; World Health Organisation, 2009). Overweight and obesity, physical inactivity and dietary risk factors are all associated with increased urbanisation (Wu et al., 2015), and as low-income countries become wealthier there tends to be an increased burden of disease attributable to these three risk factors along with alcohol and tobacco use (World Health Organisation, 2009). In our study, this may partially explain why participants born in Sub-Saharan Africa and Asian regions had lower mean CDRI scores than Australian-born participants while participants born in American and European regions and the Middle East and North Africa had equal or higher CDRI scores, and the trend of increasing CDRI score with increasing years lived in Australia.

While individual risk factor analysis is informative, it cannot be used to estimate the overall level of chronic disease risk. For example, participants born in the three Asian regions had relatively high RRs of physical inactivity and inadequate fruit and vegetable intake, however they had the lowest mean CDRI scores. Conversely, participants born in Western Europe, Eastern and Central Europe and the Middle East and North Africa had relatively low RRs of harmful alcohol consumption and inadequate fruit and vegetable intake, yet had the highest mean CDRI scores. A cohort study in Hawaii found a dose response relationship between a similar version of a CDRI and a number of chronic disease outcomes (Meng et al., 1999). Although smoking accounted for over 50% of the CDRI’s impact on mortality, and BMI 25%, the effects of negative health practises were cumulative. Therefore both individual and multiple risk factor analyses are necessary to obtain a complete picture of chronic disease risk.

This study has several limitations. Firstly, being a cross-sectional study, participants were not tracked over time, so it is possible that changing health behaviours in migrants’ country of origin over time could partially explain the apparent trends, rather than acculturation. A limitation of the 45 and Up Study is the potential for selection bias due to the relatively low response rate (18%), where participants in certain population sub-groups, such as the highly economically disadvantaged, may be under-represented. Therefore caution is needed when generalising prevalence data to the NSW population. However, a direct comparison of the 45 and Up Study with the NSW Population Health Survey found consistent exposure-outcome relationships between the two studies, including variables related to lifestyle behaviours (Mealing et al., 2010). Another limitation is that some immigrant groups may be under-represented because the questionnaire was only available in English. The proportion of immigrants who spoke a non-English language at home in this study was 32%, lower than the 53% reported for first generation immigrants in the 2011 census (Australian Bureau of Statistics, 2012). This may suggest that immigrant participants selected in this study have a higher degree of acculturation than those in the general population of NSW, and so the AMDs in CDRI score may be biased towards the null. Caution must therefore be exercised when interpreting null results.

The CDRI is likely to have greater validity than most other approaches to co-occurrence analysis due to the use of multiple risk levels and assigning weights based on impact on loss of disability-adjusted life years, however it is not without limitations. Firstly, an assumption underlying the CDRI is that multiple risk factors have an additive effect on chronic disease, and therefore any potential multiplicative effects are not captured. Secondly, the multiple risk levels defined for alcohol consumption and inadequate physical activity are based on now outdated versions of national health guidelines (Australian Government Department of Health, 2014). Furthermore, the fruit and vegetable intake risk levels are based on tertiles of intake in NSW rather than health guidelines as for the other four risk factors. Updating the CDRI to account for current alcohol, physical activity and fruit and vegetable intake guidelines would confirm that the risk levels used reflect current evidence. Finally, a disadvantage common to all methods of co-occurrence analysis/combining risk factors, including the CDRI, is that they do not provide information about statistical associations between each of the individual risk factors (McAloney et al., 2013). An alternative method would be cluster analysis, where ascertaining the strength of relationships between risk factors means that risk factors that commonly occur together can be grouped and used to identify sub-populations with qualitatively different risk profiles (e.g. (Griffin et al., 2014)).

**Conclusion**

This study reveals differences in potential risk of chronic disease across immigrant groups in Australia. These results will assist policy makers in targeting culturally appropriate chronic disease prevention programmes to the groups with the highest need, and the specific behavioural risk factors to target for maximum impact on burden of disease in different immigrant groups. Future work in this area will focus

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### Table 3

Chronic disease risk index (CDRI) by place of birth in the 45 and Up Study (2006–2009), New South Wales, Australia.

<table>
<thead>
<tr>
<th>Place of birth</th>
<th>Mean CDRI score (SD)</th>
<th>Adjusted* mean difference in CDRI score from Australian-born participants</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>23.0 (16.7)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>New Zealand</td>
<td>22.6 (16.4)</td>
<td>-0.5</td>
<td>-0.9</td>
<td>0.0</td>
<td>0.06</td>
</tr>
<tr>
<td>Oceania</td>
<td>22.5 (16.9)</td>
<td>-0.9</td>
<td>-2.1</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>East Asia</td>
<td>14.9 (12.9)</td>
<td>-7.2</td>
<td>-7.8</td>
<td>-6.6</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>16.0 (13.8)</td>
<td>-6.6</td>
<td>-7.2</td>
<td>-6.1</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Central &amp; South Asia</td>
<td>18.6 (14.8)</td>
<td>-3.1</td>
<td>-4.0</td>
<td>-2.1</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>UK &amp; Ireland</td>
<td>22.5 (16.0)</td>
<td>-2.2</td>
<td>-0.5</td>
<td>0.0</td>
<td>0.03</td>
</tr>
<tr>
<td>Western Europe</td>
<td>23.0 (16.1)</td>
<td>0.5</td>
<td>0.1</td>
<td>0.8</td>
<td>0.007</td>
</tr>
<tr>
<td>Eastern &amp; Central Europe</td>
<td>24.6 (16.0)</td>
<td>1.3</td>
<td>0.8</td>
<td>1.9</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Middle East &amp; North Africa</td>
<td>27.7 (17.3)</td>
<td>3.5</td>
<td>2.7</td>
<td>4.3</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>19.6 (14.9)</td>
<td>-1.9</td>
<td>-2.6</td>
<td>-1.2</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>North America</td>
<td>20.1 (15.2)</td>
<td>-0.7</td>
<td>-1.5</td>
<td>0.1</td>
<td>0.08</td>
</tr>
<tr>
<td>Central &amp; South America</td>
<td>23.0 (16.2)</td>
<td>-0.3</td>
<td>-1.3</td>
<td>0.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Total immigrants</td>
<td>22.0 (16.0)</td>
<td>-0.8</td>
<td>-1.0</td>
<td>-0.6</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Total</td>
<td>22.7 (16.5)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

SD, Standard Deviation. CI, Confidence Interval.

* Adjusted for sex, age, remoteness, education level, marital status, household income and health insurance status.
on quantifying health outcomes in relation to the CRDI over time. It will be of interest whether the regions of birth identified in our study will have higher than average rates of chronic disease in the future.

Conflicts of interest statement

The authors declare that there are no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.jypmed.2015.09.004.

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