Demographic projections of future pharmaceutical consumption in the Netherlands
N. G. F. M. van der Aa, G. J. Kommer, J. E. van Montfoort and J. F. M. Versteegh

ABSTRACT
Over the next few decades, many Western European countries will undergo a large demographic transformation introduced by the retirement of the “baby boomers” and the possibility of striking increases in longevity. The aim of this study was to estimate the effect of a growing and ageing Dutch population on the future consumption of pharmaceuticals, so as to be able to anticipate the potential future emissions of these pharmaceuticals and their residues to surface waters. A total of 354 prescribed pharmaceuticals from 40 therapeutic groups was selected for study. These constitute 1.251 metric tonnes (98%) of the total Dutch consumption of prescribed pharmaceuticals in 2007. Calculations based on a fixed consumption rate (2007) predict that demographic developments can be expected to push consumption up to 1.504 metric tonnes in 2020 (+17%) and 1.851 metric tonnes by 2050 (+37%). Therapeutic groups showing the largest increase are related to illnesses associated with old age. The only groups showing a decrease are the antivirals and drugs for addiction treatments as well as ethinylestradiol, an active compound in contraceptives.

Key words | ageing, population, prescribed pharmaceuticals, surface water, water authorities

INTRODUCTION
A wide range of pharmaceuticals have been found in wastewater effluents and surface waters of several countries (Halling-Sørensen et al. 1996; Ternes 1998; Kümmerer 2000; Kolpin et al. 2002; GWRC 2004). In the Netherlands, public awareness and concern on the occurrence and effects of pharmaceuticals and their residues throughout the water cycle, have been growing since the late 1990s. A number of Dutch studies (Mons et al. 2000; Schrap et al. 2003; Kiwa 2004) have demonstrated the presence of high concentrations of pharmaceuticals in the effluents of wastewater treatment plants (range: 1000–10,000 ng/l) and substantially lower concentrations in the receiving surface water (range: 100–1000 ng/l). Pharmaceuticals have only rarely been found in Dutch drinking water. On the few occasions that they have been detected, concentrations were usually below 10–50 ng/l, although higher levels have been reported, with 136 ng/l for clofibrinic acid being the maximum concentration reported to date (Versteegh et al. 2007). Effects on human health are unlikely at these concentrations (Mons et al. 2003; Versteegh et al. 2003, 2007), but the long-term effects are less clear as the necessary toxicity data are lacking. Mass balance studies of consumption and loads in the Rhine river show that substantial fractions of consumed pharmaceuticals can be recovered from this river, which is an important source of drinking water in the Netherlands (Ter Laak et al. 2009).

In order to reduce future emissions of pharmaceuticals to the water environment, the Dutch government established an interdisciplinary working group in 2007, comprising expert stakeholders from the government, the academic world and the pharmaceutical industries. This working group has issued an inventory of cost-effective measures aimed at reducing the future emissions of pharmaceuticals to the water environment. Among others, these measures include a more restrictive use of human and veterinarian pharmaceuticals and...
the collection and management of unused pharmaceuticals. Several pilot projects have been initiated that focus on urine source separation and the separate treatment of hospital wastewater (Stowa 2009). Wastewater treatment plants are currently being upgraded to meet the water quality goals established by the Water Framework Directive (WFD). These measures will likely have a very limited effect on reducing the emission of pharmaceuticals to the surface water. For this purpose, more advanced sewage treatment technologies need to be implemented, such as active carbon filtration or ozonation, both of which have a great potential for reducing the emission of pharmaceuticals to receiving waters (Kools & Knacker 2006; van Betuw et al. 2008). The treatment of drinking water can result in an 80–100% removal rate, depending on the pharmaceutical and the treatment steps (van den Berg et al. 2007). Since improvements to wastewater and drinking water treatment plants are expensive investments that focus on the long term (decades), accessible information on the consumption of specific (groups of) pharmaceuticals that are expected to increase in the future can help stakeholders focus on these improvements.

Demographic developments are major determinants of the future use of health care services (Post & Stokx 1997; Meerdink et al. 1998; van den Berg Jeths et al. 1999; Polder et al. 2002, 2006). In the Netherlands, as in many other industrialised countries, the proportion of elderly in the population is predicted to increase considerably during the next few decades (OECD 2005; CBS 2009). The ageing of the population is caused by the combined effects of increased longevity, the ageing of the large birth cohort born around 1950 (the “baby boomers”) and the subsequent relatively smaller birth cohorts. An ageing population is an important factor contributing to the rapid growth of health care expenditure, since per capita health care costs are strongly age-dependent (Polder et al. 2002a, 2006). Based on an analysis of the demographic developments expected in the period up to 2025 in the Netherlands, de Hollander et al. (2007) demonstrate that the largest rises in prevalence are expected in the illnesses associated with old age, such as heart failure (40% population ageing-driven increase), dementia (38%) and stroke (37%). Concomitantly, the disorders that mainly affect younger people, such as asthma and mental disabilities, become less prominent. Chronic diseases are more prevalent in “old age”, and the consumption of pharmaceuticals is also greater among the elderly (Polder et al. 2002b).

The primary aim of this study was to investigate how the predicted ageing population may affect the future consumption of pharmaceuticals. Here, we attempt to quantify future consumption due to growth and ageing of the Dutch population in the period 2007–2020–2050.

METHODOLOGY

Data on the consumption of prescribed pharmaceuticals were provided by the Foundation for Pharmaceutical Statistics in the Netherlands (SFK). The SFK directly gathers its data from a consortium of pharmacies that currently comprise 1.760 (90%) of the 1.940 community pharmacies in the Netherlands (SFK, 2008). To correct for this under-representation, we multiplied the SFK data with a factor 10/9, assuming that these 1.760 pharmacies are representative of the Netherlands. The consumption data in the SFK database do not include pharmaceuticals for hospital use or veterinary use nor do they include pharmaceuticals that can be purchased over-the-counter (OTC). Pharmaceutical consumption was expressed as the number of DDDs (daily defined doses) on ATC5-level (Anatomical Therapeutic Chemical classification system for pharmaceuticals), specified to age and gender. The amount of active compound per DDD was subsequently calculated per ATC5. Total consumption was calculated per pharmaceutical active compound, which for most pharmaceuticals is represented by several ATC5-codes. Gasses, solvents, inorganic salts, auxiliary matter, proteins, vitamins, amino acids and vegetable extracts were removed from the dataset.

The projections for future consumption were performed for a total of 354 prescribed pharmaceuticals, belonging to 40 therapeutic groups. The pharmaceuticals were selected if they met at least one of the following criteria:

1. The pharmaceuticals are considered to be priority pharmaceuticals by Dutch drinking water companies (Mons 2004; van den Berg et al. 2007). Selection is based primarily on their occurrence in the water system and their resistance to treatment.
2. The pharmaceuticals are considered to be priority pharmaceuticals by the Global Water Research Coalition (GWRC 2008; de Voogt et al. 2009). Selection is based on the criteria regulation, consumption, physicochemical properties, toxicity, occurrence in surface waters, groundwater and drinking water, persistence and resistance to treatment.
3. Total consumption of the pharmaceuticals in the Netherlands in 2007 > 65 kilograms.
4. The pharmaceuticals were selected by Lienert et al. (2007a, b) because they belong to the top 100 most sold
pharmaceuticals in Switzerland in 2004, and Dutch consumption data are also available for these pharmaceuticals.

5. The pharmaceuticals are listed by Barcelo & Petrovic (2007), a handbook on the analysis and fate of pharmaceuticals in the water cycle and their removal in wastewater and drinking water treatment.

An additional 33 'priority' pharmaceuticals were selected that meet the criteria 1 or 2 above, or they belong to the top 50 of prescribed pharmaceuticals with the highest consumption rates in 2007 in the Netherlands that are also excreted in the urine unchanged at a level of >50% (van der Aa et al. 2008).

Future consumption of pharmaceuticals was calculated using Statistics Netherlands' forecast of demographic changes in the Dutch population for the period 2007–2020–2050 (Statline 2008). The impact of an ageing population on future consumption has been projected by multiplying current (2007) age- and gender-specific consumption by the future number of individuals per age group and gender.

RESULTS AND DISCUSSION

Pharmaceutical consumption in the Netherlands in 2007

In 2007, the total consumption of prescribed pharmaceuticals obtained through pharmacies in the Netherlands amounted to approximately 1.273 metric tonnes (about 78 grams per person). The 354 pharmaceuticals selected for study constitute 1.251 metric tonnes kg (98%) of this total consumption (about 76 grams per person). Gastrointestinal drugs (drugs for peptic ulcer and gastro-oesophageal reflux disease, intestinal anti-inflammatory agents and other alimentary tract and metabolism products) and antidiabetics are the largest contributors to this total, at 426 and 266 metric tonnes, respectively. Analgesics account for 139 metric tonnes. In 2007, the therapeutic groups antihypertensives, antirheumatics, anti-epileptics, antithrombotic agents, antidepressants/antipsychotics, lipid-modifying agents, drugs for cough preparations and antiinfectives (antibiotics), each accounted for between 10 and 100 metric tonnes. Antiinfectives cover antibacterials (both naturally produced and synthetic), antimycotics, antimycobacterials, and antivirals for systemic use. The remaining pharmaceutical groups accounted for less than 10 metric tonnes in 2007.

The total consumption of carbamazepine and ethinylestradiol, an oestrogen and active compound in contraceptives, amounted to resp. 9333 and 16 kg in 2007. This works out to an average per capita consumption (both males and females) of resp. 1.56 and 0.0028 mg per day. However, as Figure 1 shows, carbamazepine is consumed throughout the population, while ethinylestradiol is predominantly used by females in the age classes 15–24 and 25–44 years.

Future consumption for all 354 pharmaceuticals belonging to 40 therapeutic groups

The Dutch population can be expected to increase from 16.4 million people in 2007 to 16.8 million in 2020 (2.4% increase), and to 16.8 million in 2050 (2.7% increase) (Statline 2008). The largest increase will occur in the number of elderly, while the number of individuals aged 0–64 years will decrease (Figure 2).

Calculations based on a fixed age- and gender- specific consumption rate (2007) show that demographic developments will push consumption up from about 1.251 metric

tonnes in 2007 to 1.504 metric tonnes in 2020 (+17%) and to 1.851 metric tonnes by 2050 (+37%). Groups of pharmaceuticals showing the biggest increase are related to illnesses associated with old age. Anti-parkinson drugs, cardiac glycosides, cough preparations, vasodilatators, urologicals and musculo-skeletal disorder agents belong to the top ten increasing pharmaceuticals during the periods 2007–2020 and 2007–2050. Drugs for obstructive airway diseases, antiarrhythms, anticancer drugs, antivertigo preparations, bisphosphonates, potassium-binding drugs, analgesics, ophthalmological agents and gastrointestinal drugs belong to the top twenty increasing pharmaceuticals in these periods. The only pharmaceutical groups that show a decline are the antivirals (−1%) and drugs for addiction treatments (−3%).

Future consumption for 33 selected ‘priority’ pharmaceuticals

Table 1 shows the predicted effects of demographic developments on the future consumption of 33 selected pharmaceuticals based on projections of demographic changes in the Dutch population between 2007 and 2050. Results are given per pharmaceutical group.

![Figure 2](https://iwaponline.com/wst/article-pdf/63/4/825/445463/825.pdf)
pharmaceuticals. The results show an increase from about 555 metric tonnes in 2007 to 667 in 2020 (+20%) and to 756 in 2050 (+36%). Antigout (metabolic arthritis) medicines, pharmaceuticals for cardiovascular diseases, antidiabetic drugs, analgesics and antidepressants/tranquilisers show the strongest increase between 2007 and 2050. Antirheumatics, antiinfectives (antibiotics) and antiepileptics show a medium increase. The only pharmaceutical for which a decrease is expected is ethinylestradiol. This decreased consumption can be related to the decreasing number of women in the age class 25–44 years (Figures 1 and 2).

Uncertainties

Uncertainties in the demographic projections increase with increasing length of the projection period. Between 2007 and 2020, the Dutch population is expected to grow from 16.4 to 16.8 million people, with a probability of 67% that this number will range between 16.2 and 17.2 million. For the 2050 projection, this range increases (between 14.9 and 18.5 million). This means that, although it is likely that the Dutch population will increase in the coming decennia, it can not be excluded that the population will start to decrease between 2007 and 2020. This uncertainty is related to different parameters in the demographic prognosis, such as death and fertility rates, immigration and emigration numbers. The extrapolation of these uncertainties into the demographic projections of pharmaceutical consumption leads to the prediction that the total consumption will grow from 555 metric tonnes (2007) to 667 metric tonnes (2020), with a probability of 67% that this number will range between 640 (−4%) and 687 (+3%) metric tonnes. For 2050, the predicted range is between 686 (−12%) and 824 (+9%) metric tonnes. These predictions show that even if the population is declining between 2007 and 2050, the total consumption of pharmaceuticals is still expected to increase due to demographic changes like ageing.

Demographic developments Rhine and Meuse river basins

The Netherlands belongs to the cohort of European countries with the smallest difference in projected population size between 2007 and 2060 (Harbers et al. 2008). Table 2 shows that other countries that are also part of the Rhine and Meuse river basins, such as France, Belgium and Luxembourg, show a larger relative growth than the Netherlands in this period. In Germany, a decline is expected, as is the case for about half of the EU-27 Member States (Harbers et al. 2008). Because Germany has the largest number of inhabitants in the Rhine river basin, also a decline (−8%) in the number of inhabitants in the total Rhine river basin is expected in 2060, while for the Meuse river basin a growth of 3% is expected (Table 2). Effects of international demographic developments have not been taken into account in this research, but are likely to result in larger changes in future pharmaceutical consumption compared to the Netherlands, which may influence the emissions of human pharmaceuticals to the Rhine and Meuse rivers in the future.

Table 2 | Projected population change in 2060 in countries that are part of the Rhine and Meuse river basins

<table>
<thead>
<tr>
<th>Country</th>
<th>% population change 2007–2060</th>
<th>% of total inhabitants Rhine river basin in 2005</th>
<th>% of total inhabitants Rhine river basin in 2060 compared to 2005</th>
<th>% of total inhabitants Meuse river basin 2005</th>
<th>% of total inhabitants Meuse river basin in 2060 compared to 2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
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<td>0.7</td>
<td>0.7</td>
<td>–</td>
<td>–</td>
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<td>7.9</td>
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<td>8.6</td>
</tr>
<tr>
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<td>60.0</td>
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<td>22.0</td>
<td>39.7</td>
<td>40.1</td>
</tr>
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<td>Belgium</td>
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<tr>
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<td>0.5</td>
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</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>91.8%</td>
<td>100%</td>
<td>103.2%</td>
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</tr>
</tbody>
</table>

1Harbers et al. (2008)  
2ICBR (2005)  
3IMC (2008)
DISCUSSION

The use of demographic projections for quantifying future pharmaceutical consumption assumes that this future consumption will be influenced only by changes in the size and make-up of the population. In reality, however, consumption is subject to many other influences, such as epidemiological changes (for example the 2009 flu pandemic), developments in the provision of health care and medical technology. These factors are difficult to predict. Much depends not only on the technologies that come onto the market, but also on developments/changes in what society views as an appropriate level of health care.

The use of demographic projections for quantifying future pharmaceutical consumption also assumes a fixed consumption rate (in this analysis, that of 2007). This consumption rate will certainly change in the future because of the introduction of new pharmaceuticals and the expiration of patents for existing pharmaceuticals. Effects of these factors are difficult to predict. Increases in the number of individual pharmaceuticals may be lower than projected and, dependent on new developments, pharmaceuticals currently in use may be replaced by new ones with probably the same target. Therefore, we have presented the results per therapeutic group, which can be related to groups of diseases. However, the different pharmaceutical groups constitute substances with very different physicochemical properties, which are relevant for their fate in the water cycle and their removal in wastewater and drinking water treatment.

Although it is likely that the Dutch population will increase in the coming decennia, it can not be excluded that it will start to decrease between 2007 and 2020. The predictions in this research show that even if the population will decrease, the total consumption of pharmaceuticals is still expected to increase due to demographic changes like ageing and the fact that the consumption of pharmaceuticals is greater among the elderly. The consumption of some pharmaceutical groups that are related to disorders that mainly affect younger people, might decrease. The modelling exercise carried out here, although surrounded with uncertainties, reveals a quantified trend for the future that can help distinguish between probable and improbable scenario’s for future consumption and potential emissions of pharmaceuticals to the water system. Policy makers can use this information to anticipate and develop appropriate emission reduction strategies.

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