

True South Actuaries and Consultants

Bureau of Market Research (UNISA)

The SA insurance gap

Quantifying the insurance gap by reference to the financial impact on South African households of the death or disability of an active earner in the household

Nov 2010



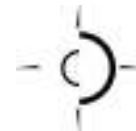
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1 INTRODUCTION

1.1 BACKGROUND AND BRIEF

In 2007, True South Actuaries and Consultants (True South), on behalf of the (then) Life Offices' Association of South Africa undertook an investigation into the extent to which life and *Disability* insurance cover for the South African pre-retirement population fall short of their real needs.

The Association for Savings and Investments SA (ASISA) has now retained True South and the Bureau of Market Research at UNISA (BMR) to update the 2007 study with updated information and new data that has since become available.

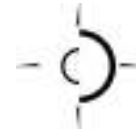
1.2 ACKNOWLEDGEMENTS

Prior to the study we had very fruitful discussions with a sample of life insurers, who added significant value to the process. In this regard we extend specific thanks to (in alphabetical order) ABSA Life, Liberty, Metropolitan, Momentum, PPS, Regent Insurance and Sanlam Developing Markets.

We also express our thanks to all the life insurers who participated in the study through the provision of data on fairly tight timelines. We saw significant improvements in both the response rate and the general quality of data, compared to the 2007 study. We are also particularly grateful for the many instances where senior officials in the respective organizations got personally involved to assist us in securing the necessary data.

In addition we would like to thank Mr. Tienie Hamman and Ms. Yolisa Ncwana from the Financial Services Board who generously assisted us with the compilation of cover information in the publically available B-statements of all the insurers who are currently registered under the Long-Term Insurance Act.

Lastly our thanks go to all the ASISA-employees who were involved throughout the process, specifically Ms. Anna Rosenberg and Ms. Janete Nel who personally attended to so much of the background logistics and arrangements.



2 EXECUTIVE SUMMARY OF FINDINGS

Growth in the level of insurance cover since 2007

R'billion	Death cover	
	2007	2010
Retail insurance	1 862	2 495
Group insurance	1 673	1 930

R'billion	Disability cover	
	2007	2010
Retail insurance	1 249	1 780
Group insurance	3 231	3 783

Since the 2007 study, retail risk cover increased at a compound rate of 10% per annum in respect of death cover and 13% compound per annum in respect of disability cover.

Group cover (which includes cover provided by self-administered pension schemes), grew at a more modest 5% compound per annum (both in respect of death and disability).

The insurance gap has increased from R10.3 trillion in 2007 to R18.3 trillion currently

R'billion	2010 Insurance Gap	
	Death	Disability
Insurance Need	11 683	18 714
Actual Cover	-4 426	-7 577
Insurance Gap	7 257	11 137
Gap as % of cover need	62%	60%

The gap now amounts to R7.3 trillion in respect of death cover and R11.1 trillion in respect of disability cover.

The increase since 2007 is due to a wider definition of total personal income employed by the BMR (which is theoretically more appropriate for the purpose of this study) and the elimination of those individuals with a "negative need for insurance" (which was previously not possible, since the BMR-data was at a summarised level). Other than these changes in methodology, the increase has been broadly in line with wage inflation.

	R'billion
2007 Insurance Gap	10 328
Expected inflation	2 863
Wider income definition	2 947
Negative need removed	1 958
Real structural increase	299
2010 Insurance Gap	18 395



The additional death cover required by a specific earner depends crucially on current personal income

Personal monthly income (net of tax)	Gap per Earner	Number of Earners	Total gap (R'billion)
R0-R3,000	0.1m	4.7m	587
R3,000-R5,800	0.4m	2.3m	956
R5,800-R8,300	0.6m	1.5m	966
R8,300-R16,700	1.0m	2.3m	2 199
R16,700+	1.5m	1.7m	2 549
All	0.6m	12.4m	7 257

With the use of statistical tools, personal income breaking points were determined so as to cluster individuals with most similar household expenditure patterns.

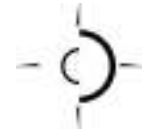
The gap increases steeply as income increases (both per earner and in total).

A response to the insurance gap in respect of death cover, could be to pro-actively purchase additional cover, while reactive responses (post the death event) may include curtailing household expenditure or increasing household income

Personal monthly income (net of tax)	Pro-active	Reactive post death event	
	Cost to close gap (% of income)	% reduction in household expenditure	Additional income per month
R0-R3,000	3.6%	29%	581
R3,000-R5,800	3.9%	34%	2 070
R5,800-R8,300	3.6%	35%	3 277
R8,300-R16,700	3.1%	31%	5 132
R16,700+	1.6%	25%	8 787
All	2.4%	30%	3 177

To close the gap in respect of death cover, a household can buy additional cover, which may cost around 2.4% of personal income on a group scheme basis.

In the absence of additional cover, the household would have to either cut expenditure by around 30% after the death of the earner, or somehow replace the income that has been lost.



The additional disability cover required by a specific earner depends crucially on current personal income

Personal monthly income (net of tax)	Gap per Earner	Number of Earners	Total gap (R'billion)
R0-R3,000	0m	4.7m	-226
R3,000-R5,800	0.5m	2.3m	1 033
R5,800-R8,300	0.9m	1.5m	1 351
R8,300-R16,700	1.6m	2.3m	3 617
R16,700+	3.2m	1.7m	5 363
All	0.9m	12.4m	11 137

Government's disability grant is very effective in protecting those earners in the bottom income bracket against disability events.

For higher earners, the average gap increases sharply (in nominal terms) in line with income.

A response to the insurance gap in respect of disability cover, could be to pro-actively purchase additional cover, while reactive responses (post the disability event) may include curtailing household expenditure or increasing household income

Personal monthly income (net of tax)	Pro-active	Reactive post <i>Disability</i> event	
	Cost to close gap (% of income)	% reduction in household expenditure	Additional income per month
R0-R3,000	-0.6%	-7%	-211
R3,000-R5,800	1.7%	27%	2 060
R5,800-R8,300	2.0%	36%	4 247
R8,300-R16,700	2.0%	39%	8 042
R16,700+	1.4%	39%	18 243
All	1.5%	34%	4 696

Households with earners earning monthly income in excess of R16,700 would need extra earnings in excess of R18,000 per month to "plug the gap" should the earner become disabled. Alternatively expenditure would have to be cut by 40%.

A pro-active alternative would be to buy additional cover (at a cost of around 1.4% of earnings on a group scheme basis).



3 STRUCTURE OF THE REMAINDER OF THIS REPORT

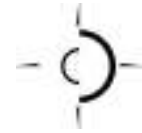
Throughout this report, terms that are defined in Appendix A are typed in *italics*.

3.1 MAIN BODY

Section 4	Macro Insurance Gap	<i>Quantifying the Insurance Gap for the South African actively earning population as a whole</i>
Section 5	Micro Insurance Gap	<i>Translating the macro gap to an average amount per South African Earner</i>
Section 6	Gap per socio-economic grouping	<i>Considering the Insurance Gap per broad socio-economic grouping (based on income)</i>
Section 7	“Slicing” the gap	<i>Analysing how the Insurance Gap varies over income, education, age and household size</i>

3.2 APPENDICES

Appendix A	Definitions and principles	<i>Definitions of terms and the main principles guiding the study</i>
Appendix B	Data sources and approach	<i>Information on the main sources of data used to determine the Insurance Need and Actual Cover</i>
Appendix C	The Insurance Need	<i>A more technical discussion on the methodology employed to derive the Insurance Need</i>
Appendix D	Actual Cover	<i>Information on how Actual Cover was allocated to individuals</i>



4 THE INSURANCE GAP AT A MACRO LEVEL

4.1 INSURANCE GAP = INSURANCE NEED – ACTUAL COVER

4.1.1 DEATH INSURANCE GAP

If South African households would want to maintain their standards of living after the death of an *Earners*, the *Insurance Need* for a death event for all employed South African *Earners* is probably in the region of R11.7 trillion (1 trillion = 1000 billion = 10^{12}).

The actual extent of death cover in force in the economy only amounts to R4.4 trillion. This leaves a death *Insurance Gap* of around R7.3 trillion.

4.1.2 DISABILITY INSURANCE GAP

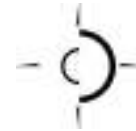
Similarly the *Insurance Need* for *Disability* cover is likely to be in the region of R18.7 trillion. Actual *Disability* cover, however, only amounts to about R7.6 trillion.

This leaves a *Disability Insurance Gap* of around R11.1 trillion.

4.1.3 DETAIL

The table below provides more detail to illustrate how the *Insurance Gap* is derived as the difference between the *Insurance Need* and the *Actual Cover*.

R'billion	Death	Disability
<i>Insurance Need</i>	11 683	18 714
Total income at risk	1 119	1 204
* Replacement ratio	68%	97%
* Capitalisation factor	15.4	15.9
<i>Actual Cover</i>	-4 426	-7 577
Insurance: Retail	-2 495	-1 780
Insurance: Group	-1 930	-3 783
Government grants	-	-2 014
<i>Insurance Gap</i>	7 257	11 137
Gap as % of cover needed	62%	60%



4.1.4 NOTES

The terms in italics are defined in Appendix A.

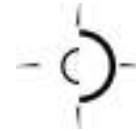
Some comments on the high-level approach can be found in Appendix B.

The three terms used to define the *Insurance Need* are each the subject of an Appendix within the C-Appendices.

The derivation of the *Actual Cover* is discussed in the D-Appendices.

Appendix D2 mentions the use of two models to derive [1] product ownership probability and [2] level of cover given ownership has been established. Some interesting findings from these models are:

- **Level of education**: There is a very strong correlation between insurance policy ownership and highest level of education attained. The likelihood of a graduate having a life insurance policy is more than 3 times higher than an otherwise identical person (with regard to income, age, gender, family composition, marital status), but with only a primary school education. For *Disability* policies this distinction is even more pronounced with the factor being almost 5 times.
- **Age**: A 50 year old person is 2.5 times more likely to own a life insurance policy compared to an otherwise identical person aged 20. For *Disability* the probability of owning a policy increases sharply until age 30 after which it remains relatively constant before reducing again after age 50.
- **Income**: A person with earnings in the top quartile is about 1.3 times more likely to have life insurance compared to an otherwise identical person (including education level, age etc.), but with earnings in the next (second) quartile. For *Disability* policy ownership this distinction is much more pronounced with the factor being 2.2.
- **Group cover**: The main determinants for the level of group cover are salaries and wages (as opposed to total personal income), age and education level.



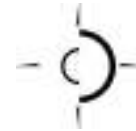
4.2 RECONCILIATION OF THE 2007 AND 2010 GAPS

Below we analyse the reasons for the change in the *Insurance Gap* (in total for death and *Disability*) from 2007.

R'billion	Note	<i>Insurance Need</i>	<i>Actual Cover</i>	<i>Insurance Gap</i>
2007 <i>Insurance Gap</i>	1	20 185	9 858	10 327
Expected inflation	2	5 597	2 734	2 864
Wider income definition	3	2 947	-	2 947
Negative need removed	4	1 958	-	1 958
Real structural increase	5	-290	-589	299
2010 <i>Insurance Gap</i>		30 397	12 003	18 395

- **Note 1:** In the previous study, the death *Insurance Gap* was reported as R4.3 trillion, and the *Disability Insurance Gap* as R6.0 trillion – i.e. a total *Insurance Gap* of R10.3 trillion.
- **Note 2:** The *Insurance Gap* is expected to grow each year in line with salary inflation.
- **Note 3:** The previous study was based on personal income reflected in a 2005 BMR-study (adjusted to allow for growth to 2007). The BMR-data used for this study considers a much wider (and theoretically more appropriate for the purpose of this study) definition of personal income. As the total personal income at risk is now assumed to be much higher than what was the case previously, the absolute size of the *Insurance Gap* increased substantially. The *Insurance Gap* as percentage of personal income, however, should not have changed materially due to this reason alone. The wider income definition should be seen as a calculation methodology change and not a real increase in the *Insurance Gap*.
- **Note 4:** This change in methodology is discussed as part of the definition of *Insurance Gap* in Appendix A. Previously this was not possible to remove negative *Insurance Need* amounts due to the summarised nature of the data available for the 2007 study.
- **Note 5:** This item is the balancing item and represents the real (above salary inflation) growth in the *Insurance Gap*.

It follows that, even though the *Insurance Gap* increased substantially, almost all of the increase relates to methodology changes and expected inflation.



4.3 RESPONSES TO THE *INSURANCE GAP*

4.3.1 PROACTIVELY INCREASE INSURANCE COVER (PRE-EVENT)

South African *Earners* could increase their death and *Disability* insurance cover.

To be able to give an indication on the cost to “close the gap”, we obtained indicative, annual premium levels (including expense, commission and profit allowance) from a number of life insurers. Information was obtained in respect of lump sum life cover and lump sum disability (total and permanent) cover, for an “average group fund member”.

As such we base our estimate for closing the *Insurance Gap* on the cost of cover in the group risk market for fairly large units of cover. The actual cost where the gap is closed by individual retail policies is likely to be substantially higher.

	Death	<i>Disability</i>
% of personal income	2.4%	1.5%
Annual cost	R35 billion	R15 billion

4.3.2 REACTIVELY REDUCE EXPENDITURE (POST-EVENT)

A household could adjust its expenditure post the death or disablement of an *Earners*. The degree to which this would have to be done is discussed in section 6 below.

4.3.3 REACTIVELY INCREASE INCOME (POST-EVENT)

Alternatively the burden of under-insurance (post-event) could be shifted to the remaining household members of working-age by requiring increased contributions to total household income. The degree to which this would be necessary is also discussed in section 6 below.



5 THE *INSURANCE GAP* AT A MICRO LEVEL

5.1 THE SIZE OF THE *INSURANCE GAP*

The *Insurance Gap* can also be presented as amounts reflecting the “average South African *Earners*”.

Rand	Death	<i>Disability</i>
<i>Insurance Need</i>	942 351	1 509 440
Total income at risk (p.a.)	90 243	97 129
* Replacement ratio	68%	97%
* Capitalisation factor	15.4	15.9
<i>Actual Cover</i>	-356 984	-611 124
Insurance: Retail	-201 274	-143 604
Insurance: Group	-155 710	-305 097
Government grants	-	-162 423
<i>Insurance Gap</i>	585 367	898 315
Gap as % of cover needed	62%	60%

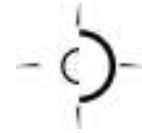
5.2 EXPECTED NUMBER OF DEATH AND *DISABILITY* EVENTS

The table below shows the number of *Earners* that will be involved (on an expected basis) in death¹ and *Disability*² events during 2011.

	Death	<i>Disability</i>
Number of <i>Earners</i>	12.4m	12.4m
Number of death / <i>Disability</i> events expected per year	159 034	52 481
Number of death / <i>Disability</i> events expected per day	435	144

¹ By reference to the demographics of the *Earners* in each segment and application of the AIDS model of the Actuarial Society of South Africa (2003).

² By reference to the most recent disability investigation of the Actuarial Society of South Africa calibrated so that ratio of disabilities to deaths is consistent with group premium rates obtained.



5.3 RESPONSES TO THE *INSURANCE GAP*

The following responses to the *Insurance Gap* were discussed earlier:

- Pro-active response: Purchasing additional insurance pre-event;
- Reactive response: Reducing household expenditure post-event;
- Reactive response: Increasing household income post-event.

The table below provides insight into the implication of each of the above options for the average South African *Earners*.

	Death	Disability
Additional insurance cover purchased (% of current income)	2.4%	1.5%
Reduction in monthly household expenditure	29.7%	33.7%
Additional monthly earnings required per month (net of tax)	R3 177	R4 696



6 THE *INSURANCE GAP* PER SOCIO-ECONOMIC GROUP

Due to the rich diversity within the South African socio-economic landscape, the concept of the “average South African *Earner*” is less clear than (say) the “average Swedish *Earner*”. For this reason, it made sense to consider the *Insurance Gap* for different socio-economic groups. It was decided to use personal income as broad indicator for socio-economic class.

6.1 SELECTION OF INCOME SEGMENT “BREAKING POINTS”

Sensible income bands were derived: Expenditure (excluding tax) was divided into broad groupings and their share of wallet determined for each of the sample points on the BMR-dataset. Agglomerative Hierarchical Cluster Analysis (AHC) was then used to determine the personal income levels with “most dissimilar” expenditure patterns.

The table below summarises the most natural (based on expenditure patterns) income break-points, depending on how many bands are required (income figures are monthly personal income net of tax).

If only two personal income segments	If three personal income segments	If four personal income segments	If five personal income segments	Number of <i>Active Earners</i> in segment (in million)
R0-R3,000	R0-R3,000	R0-R3,000	R0-R3,000	4.7
R3,000+	R3,000-R8,300	R3,000-R5,800	R3,000-R5,800	2.3
		R5,800-R8,300	R5,800-R8,300	1.5
	R8,300+	R8,300+	R8,300-R16,700	2.3
			R16,700+	1.7



6.2 THE SIZE OF THE *INSURANCE GAP* PER SEGMENT

The tables below highlight how different the *Insurance Gap* is for the different segments. We show figures for the “average *Earners*” within each segment.

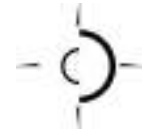
6.2.1 DEATH *INSURANCE GAP*

Rand	R0- R3,000	R3,000- R5,800	R5,800- R8,300	R8,300- R16,700	R16,700+
<i>Insurance Need</i>	133 372	483 301	800 628	1 408 200	3 325 942
Total income at risk	10 738	39 710	68 921	128 185	349 208
* Replacement ratio	68.7%	72.4%	72.1%	69.3%	65.9%
* Capitalisation factor	18.1	16.8	16.1	15.9	14.5
<i>Actual Cover</i>	-7 318	-65 628	-167 138	-431 635	-1 802 173
Insurance: Retail	-1 360	-19 554	-64 896	-220 258	-1 105 521
Insurance: Group	-5 957	-46 074	-102 242	-211 377	-696 652
Government grants	-	-	-	-	-
<i>Insurance Gap per Earner</i>	126 054	417 674	633 490	976 565	1 523 768
Gap as % of cover needed	95%	86%	79%	69%	46%
Number of <i>Earners</i> (million)	4.7	2.3	1.5	2.3	1.7
Total <i>Insurance Gap</i> (R'bn)	587	956	966	2 199	2 549

For example, an *Earners* earning between R8,300 and R16,700 per month would typically need life cover of about R1.4m. Typically such an *Earners* would only have cover slightly higher than R0.4m, leaving an *Insurance Gap* of almost R1m.

6.2.2 DISABILITY *INSURANCE GAP*

Rand	R0- R3,000	R3,000- R5,800	R5,800- R8,300	R8,300- R16,700	R16,700+
<i>Insurance Need</i>	235 744	777 277	1 270 763	2 227 830	5 309 603
Total income at risk	12 589	43 377	74 657	136 826	373 208
* Replacement ratio	97.6%	98.1%	97.9%	97.8%	97.1%
* Capitalisation factor	19.2	18.3	17.4	16.6	14.6
<i>Actual Cover</i>	-284 346	-325 728	-385 047	-621 934	-2 103 374
Insurance: Retail	-553	-10 254	-35 142	-151 436	-812 846
Insurance: Group	-13 597	-104 601	-220 634	-442 257	-1 283 745
Government grants	-270 196	-210 873	-129 271	-28 242	-6 783
<i>Insurance Gap per Earner</i>	-48 602	451 548	885 716	1 605 896	3 206 229
Gap as % of cover needed	-21%	58%	70%	72%	60%
Number of <i>Earners</i> (million)	4.7	2.3	1.5	2.3	1.7
Total <i>Insurance Gap</i> (R'bn)	-226	1 033	1 351	3 617	5 363



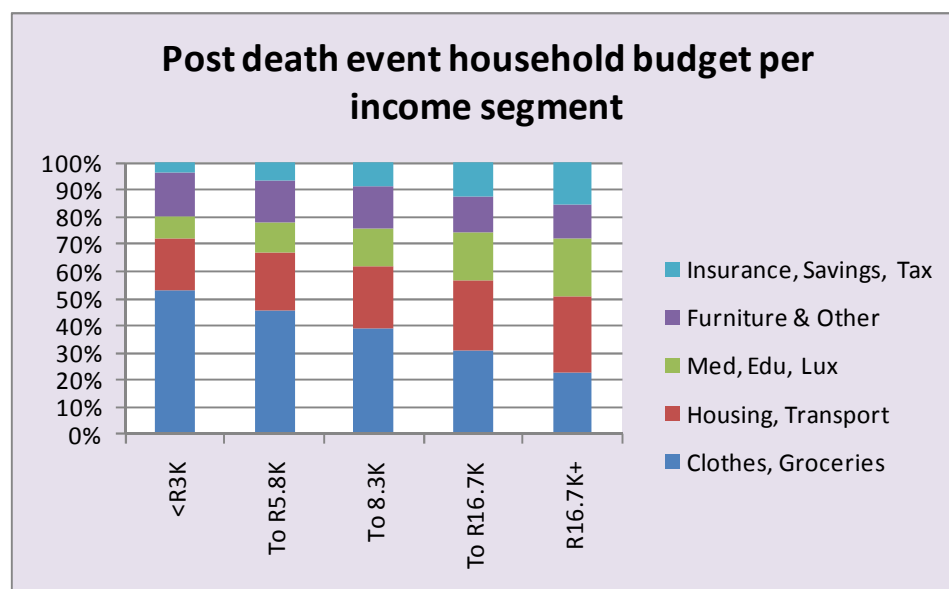
6.3 RESPONSES TO THE *INSURANCE GAP* PER SEGMENT

6.3.1 DEATH GAP

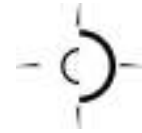
The table below gives an indication of the number of deaths and *Disability* events expected per day for the 2011 calendar year for each of the segments. It also shows (for each of the segments) the degree of intervention required for each of the three possible responses described above.

	R0- R3,000	R3,000- R5,800	R5,800- R8,300	R8,300- R16,700	R16,700 +	Total
<i>Earners</i> (million)	4.7	2.3	1.5	2.3	1.7	12.4
Deaths expected per day	217	83	49	55	32	435
Cost of insurance (as % of earnings)	3.6%	3.9%	3.6%	3.1%	1.6%	2.4%
Reduction in monthly household expenditure	29%	34%	35%	31%	25%	30%
Extra income required per month (net of tax)	R581	R2 070	R3 277	R5 132	R8 787	R3 177

The average household budget looks very different for the different segments. The following graph illustrates this, showing the “share of wallet” per segment for different broad expenditure categories.



(Med = Medical and Dental, Edu = Education, Lux include items such as holiday and domestic workers.)

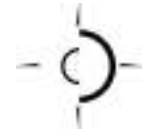


The average household budget (post event and per month) for each of the segments is as follows:

Rand per month	R0- R3,000	R3,000- R5,800	R5,800- R8,300	R8,300- R16,700	R16,700+
Clothes & Groceries	1 042	2 802	3 707	5 003	7 988
Housing	291	940	1 501	2 963	6 477
Transport	95	360	688	1 256	3 310
Medical and Dental	50	223	488	1 261	3 027
Education	51	185	382	713	1 904
Insurance / Savings	43	240	470	1 092	2 914
Recreation / Domestic	62	271	458	928	2 529
Furniture	71	229	368	626	1 347
Other	242	729	1 066	1 555	2 996
Tax	27	166	362	900	2 378
Total	1 973	6 144	9 490	16 298	34 870

For example:

- There are about 1.5 million *Earners* earning between R5,800 and R8,300 per month. It is expected that 49 *Earners* in this group will die each day during 2011 (i.e. about 18 thousand per year).
- For the average such *Earner*, it would cost about 3.6% of earnings to ensure that his/her household can maintain its current standard of living, in the event of his/her death.
- Should cover, however, remain at current levels, the average household that loses a member to death, where this member earned between R5,800 and R8,300, would have to cut back about 35% on all expenditure. This means finding savings of R3,277 per month on a current budget of R9,490.
- Alternatively, remaining household members of working age would have to start earning an additional R3,277 per month (net of tax).



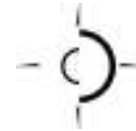
6.3.2 DISABILITY GAP

For the *Disability* event, the figures are as follows:

	R0- R3,000	R3,000- R5,800	R5,800- R8,300	R8,300- R16,700	R16,700 +	Total
<i>Earners</i> (million)	4.7	2.3	1.5	2.3	1.7	12.4
Disability events expected per day	62	28	17	22	15	144
Cost of insurance (as % of earnings)	-0.6%	1.7%	2.0%	2.0%	1.4%	1.5%
Reduction in monthly household expenditure	-7%	27%	36%	39%	39%	34%
Extra income required per month (net of tax)	-R211	R2 060	R4 247	R8 042	R18 243	R4 696

The average household budgets (maintaining current living standards) post-event would be as follows:

Rand per month	R0- R3,000	R3,000- R5,800	R5,800- R8,300	R8,300- R16,700	R16,700+
Clothes & Groceries	1 459	3 551	4 726	6 363	10 047
Housing	371	1 067	1 665	3 192	6 900
Transport	144	479	887	1 596	4 280
Medical and Dental	85	307	623	1 575	3 806
Education	65	218	421	767	2 067
Insurance / Savings	81	316	603	1 334	3 412
Recreation / Domestic	85	291	511	978	2 696
Furniture	89	253	411	694	1 501
Other	387	980	1 479	2 127	4 004
Tax	79	215	597	1 829	7 882
Total	2 847	7 677	11 923	20 456	46 595



7 VARIOUS VIEWS ON THE *INSURANCE GAP*

7.1 BY PERSONAL INCOME LEVEL

7.1.1 CATEGORIES

Each *Earners* is allocated to one of ten percentile groups:

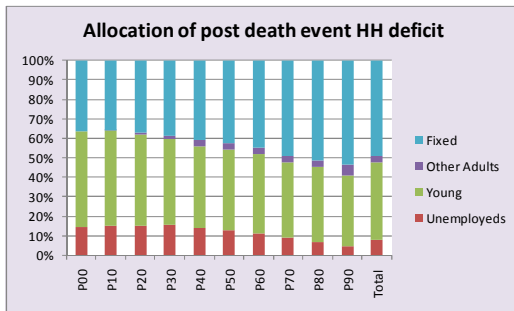
- P00: The 10% lowest earning *Earners*
- ...
- P90: Top 10% earning *Earners*

7.1.2 INFORMATION FOR EACH OF THE CATEGORIES

		# (mio)	Ave Age	% with Ins Need	Ave pa PI at risk	Gap%
Death	P00	1.2	35	50%	2 700	99%
	P10	1.2	37	64%	8 234	97%
	P20	1.2	37	66%	13 883	95%
	P30	1.2	38	69%	21 838	92%
	P40	1.2	37	78%	36 787	88%
	P50	1.2	37	81%	53 803	83%
	P60	1.2	38	82%	75 764	77%
	P70	1.2	38	85%	112 999	73%
	P80	1.2	39	84%	176 717	64%
	P90	1.2	41	80%	399 391	42%
	Total	12.4	38	74%	90 243	62%
As could probably have been expected, there is a persistent increase in the average age as one moves up in the earnings percentiles.						
The % of <i>Earners</i> where a death <i>Insurance Need</i> exists is quite low at the lower end of the earnings-scale. Many of these <i>Earners</i> would be net consumers within their respective households.						
At the very high end of the scale, the percentage drops again. In this category, the proportion of personal income that is not dependant on the <i>Earners</i> being alive or well (e.g. rental income, dividends, rental income) is much higher.						
		# (mio)	Ave Age	% with Ins Need	Ave pa PI at risk	Gap%
Disability	P00	1.2	35	65%	3 564	-268%
	P10	1.2	37	76%	9 809	-53%
	P20	1.2	37	76%	15 982	3%
	P30	1.2	38	80%	25 240	39%
	P40	1.2	37	85%	39 870	56%
	P50	1.2	37	88%	58 285	64%
	P60	1.2	38	89%	82 021	72%
	P70	1.2	38	91%	120 193	74%
	P80	1.2	39	91%	189 950	69%
	P90	1.2	41	86%	426 043	59%
	Total	12.4	38	83%	97 129	60%



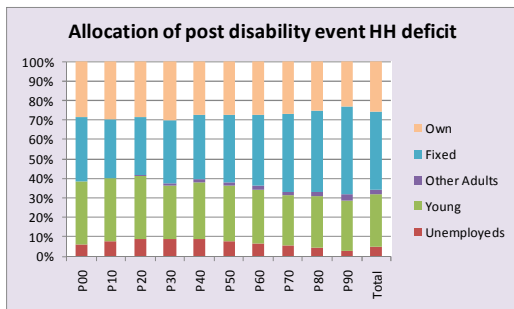
7.1.3 COMPONENTS OF HOUSEHOLD BUDGET DEFICIT (POST EVENT)



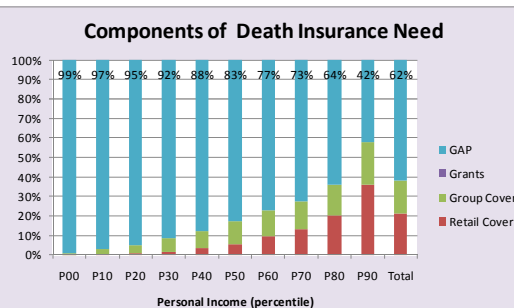
Lower earning *Earners* tend to be in households with higher exposures to members that are unemployed.

Higher earning *Earners* tend to be in households with higher exposures to housewives (included in "Other Adults" on the graphs).

Also, as income increases, there is a persistent reduction in the portion of the *Household Budget Deficit (post event)* that is directed towards (the reducing average number of) children.

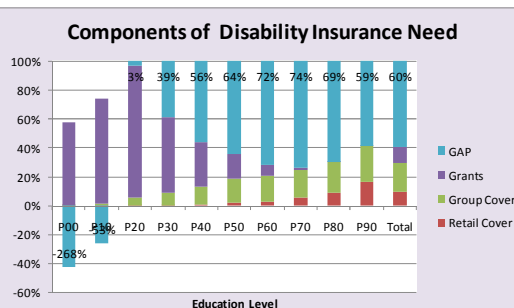


7.1.4 THE COMPONENTS OF INSURANCE NEED



The death *Insurance Gap* reduces as income increases. The same applies for the *Disability Insurance Gap*, but with a more complicated pattern due to the operation of the government grant.

Contrary to low *Earners*, high *Earners* typically have more retail death cover than group death cover. For all income groups, group *Disability* cover exceeds individual *Disability* cover.



Government *Disability* grants are directed towards lower earning individuals. The level (maximum R1,000 per month) is often more than what these *Earners* would have earned. The *Disability Insurance Gap* is therefore negative at the very low income categories.



7.2 BY EDUCATION LEVEL

7.2.1 CATEGORIES

Each *Earners* is allocated to one of six education categories depending on the highest level of education achieved:

- No PS: Never completed any schooling graded
- PS: At least some primary school
- Some HS: Completed primary school, but not high school.
- Matric: Completed high school
- Dipl: Diploma
- Degr: Degree

7.2.2 INFORMATION FOR EACH OF THE CATEGORIES

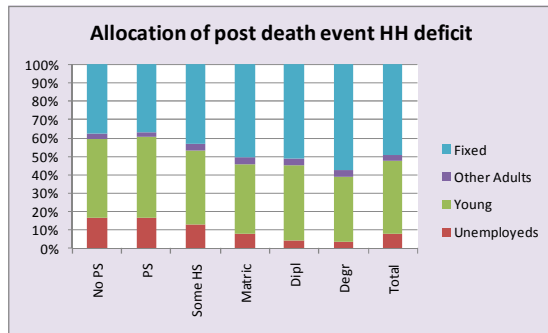
		# (mio)	Ave Age	% with Ins Need	Ave pa PI at risk	Gap%
Death	No PS	3.1	42	66%	30 593	87%
	PS	1.0	39	71%	39 247	83%
	Some HS	3.7	37	73%	57 762	77%
	Matric	2.5	34	79%	114 386	67%
	Dipl	1.2	37	82%	185 693	55%
	Degr	0.8	39	79%	294 630	38%
	Total	12.4	38	74%	90 243	62%
		# (mio)	Ave Age	% with Ins Need	Ave pa PI at risk	Gap%
Disability	No PS	3.1	42	76%	33 970	51%
	PS	1.0	39	80%	42 487	55%
	Some HS	3.7	37	83%	62 019	60%
	Matric	2.5	34	87%	121 495	65%
	Dipl	1.2	37	90%	199 591	60%
	Degr	0.8	39	87%	318 962	55%
	Total	12.4	38	83%	97 129	60%

Average age has a V-shape if plotted against education level. The down-shape may have something to do with lack of access to primary education in the past. The increasing average age for those with at least matric seems intuitive.

A higher education level is associated with higher personal income (as one would expect).

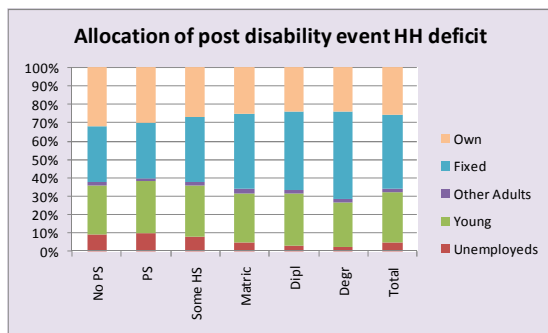


7.2.3 COMPONENTS OF HOUSEHOLD BUDGET DEFICIT (POST EVENT)

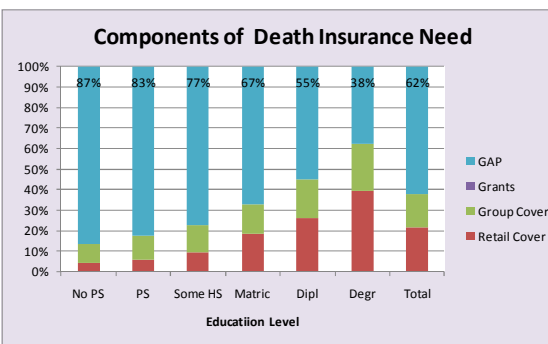


Less educated *Earners* tend to be in households with higher exposures to members that are unemployed.

As the level of education increases, there is a small but persistent reduction (from 44% to 35% for death insurance) in the portion of the *Household Budget Deficit (post event)* that is directed towards (the reducing average number of) children.

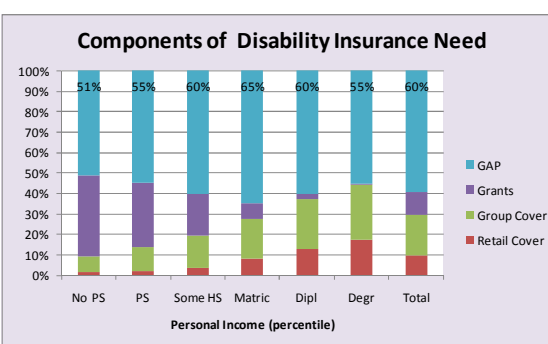


7.2.4 THE COMPONENTS OF INSURANCE NEED



The death *Insurance Gap* reduces as the education level increases. A more complicated pattern is observed for the *Disability Insurance Gap* where, for lower educated *Earners*, the government grant often replaces the income at risk to a *Disability* event.

There is a marked correlation between level of education and actual retail cover.



The pattern of *Insurance Gap* over different education categories is similar to that observed for personal income categories. There is obviously significant correlation between income and education.



7.3 BY AGE GROUP

7.3.1 CATEGORIES

Each *Earners* is allocated to one of 8 age-groups:

- 16-17
- 18-29
- 30-34
- 40-44
- 45-50
- 50-54
- 55+

7.3.2 INFORMATION FOR EACH OF THE CATEGORIES

		# (mio)	Ave Age	% with Ins Need	Ave pa PI at risk	Gap%
Death	16-17	0.0	17	58%	15 159	99%
	18-29	3.0	25	74%	62 543	81%
	30-34	2.1	32	77%	88 643	74%
	35-39	2.1	37	76%	106 005	65%
	40-44	1.8	42	77%	107 111	57%
	45-49	1.4	47	74%	107 808	39%
	50-54	1.0	52	71%	105 703	1%
	55+	1.0	59	60%	78 635	-161%
Total		12.4	38	74%	90 243	62%
		# (mio)	Ave Age	% with Ins Need	Ave pa PI at risk	Gap%
Disability	16-17	0.0	17	65%	15 829	64%
	18-29	3.0	25	86%	71 211	61%
	30-34	2.1	32	86%	95 199	62%
	35-39	2.1	37	84%	113 693	61%
	40-44	1.8	42	84%	113 485	58%
	45-49	1.4	47	81%	113 399	54%
	50-54	1.0	52	77%	110 805	52%
	55+	1.0	59	67%	83 900	36%
Total		12.4	38	83%	97 129	60%

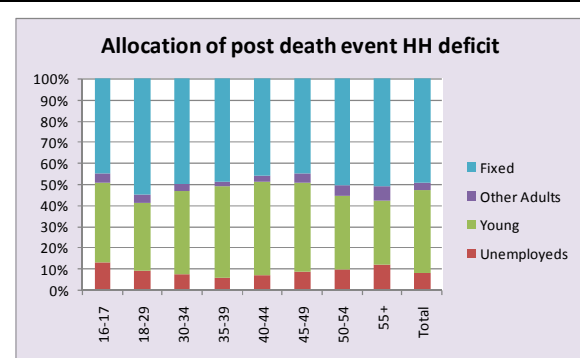
The average personal income at risk reduces towards the older ages. This has more to do with the fact that we are considering "at risk" income only than with the level of total earnings of those 50+ (which does increase over all age-categories).

For *Earners* with no *Insurance Need* (net consumers of household resources), the income at risk would be zero. For *Earners* with personal income not dependant on them being alive or well, income at risk would also be zero.

Less of the total income earned by *Earners* in the 50+ categories is "at risk".



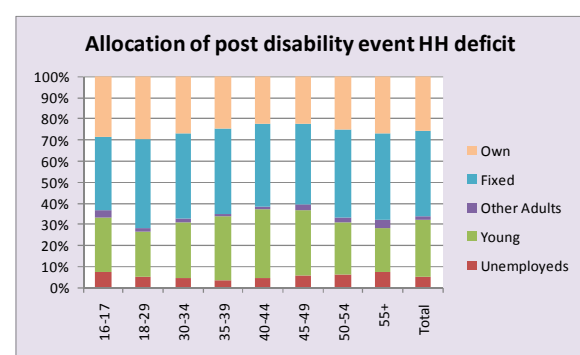
7.3.3 COMPONENTS OF HOUSEHOLD BUDGET DEFICIT (POST EVENT)



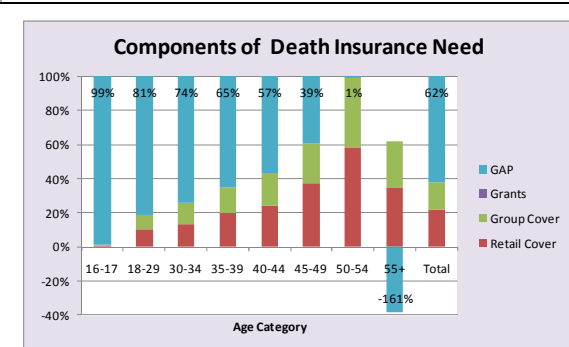
The proportion of the *Household Budget Deficit (post event)* that is related to children increases until about age 50 after which it starts to decrease again. This seems intuitive if one considers typical family structures.

Interesting however (and not apparent from the graphs in this section) is that the capitalised need is fairly stable as younger *Earners* tend to have younger children for which provision need to be made for a longer period.

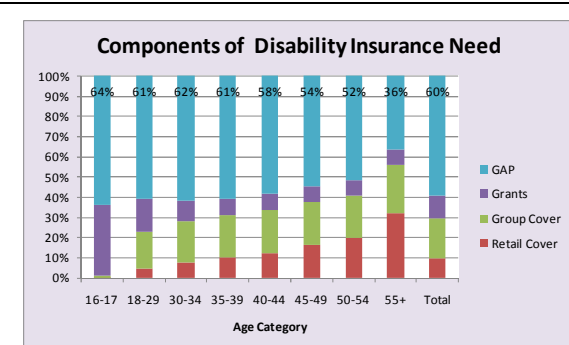
The proportion of *Household Budget Deficit (post event)* directed towards housewives (included in "Other Adults" on the graphs) increases consistently from age 40 onwards.



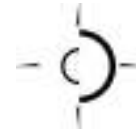
7.3.4 THE COMPONENTS OF INSURANCE NEED



The death *Insurance Gap* reduces with age. This is due to the interaction of the following: [1] increasing probability of insurance product ownership, [2] reducing *Insurance Need* (term is related to remaining working life) and [3] few structured cover reductions as policyholders become older. The *Disability Insurance Gap* is much more constant over ages. A significant portion of cover (group *Disability* income insurance) is in the form of an annuity which is usually a better match for the *Insurance Need*.



Only about 60% of 55+ *Earners* have a need for death insurance. Some are single due to changes in marital status and others have a big proportion of earnings independent of the *Earners* being alive or well. It would seem as more could be done by financial advisors to ensure *Actual Cover* remains relevant for an ageing client.



7.4 BY HOUSEHOLD SIZE

7.4.1 CATEGORIES

Each *Earners* is allocated to one of 5 categories depending on the number of members in the household (themselves included):

- 1
- 2
- 3-4
- 5-6
- 7+

7.4.2 INFORMATION FOR EACH OF THE CATEGORIES

		# (mio)	Ave Age	% with Ins Need	Ave pa PI at risk	Gap%
Death	1	1.8	37	43%	39 722	-55%
	2	1.9	38	82%	105 180	61%
	3-4	4.0	37	81%	124 518	61%
	5-6	2.6	39	79%	91 605	65%
	7+	2.0	39	75%	50 760	78%
	Total	12.4	38	74%	90 243	62%
		# (mio)	Ave Age	% with Ins Need	Ave pa PI at risk	Gap%
Disability	1	1.8	37	90%	81 210	63%
	2	1.9	38	85%	106 978	63%
	3-4	4.0	37	83%	125 512	59%
	5-6	2.6	39	80%	92 237	57%
	7+	2.0	39	75%	51 078	52%
	Total	12.4	38	83%	97 129	60%

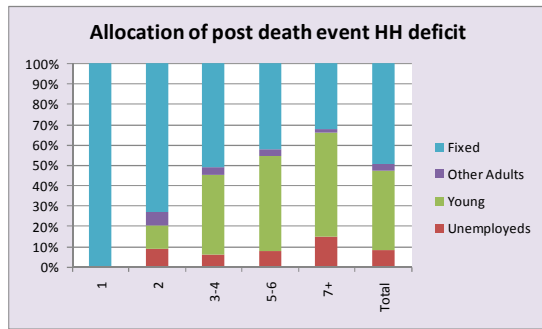
This information shows that *Earners* within larger households typically earn less relative to those in smaller households.

Earners who live alone also have relatively low earnings. This group is quite diverse, with exposure to a young not-yet-married group, but also widow(er)s and divorcees.

It is perhaps surprising that the % of *Earners* living alone with death *Insurance Need* is so high (at 43%). This is because it was decided to leave "support to relatives" as a death *Insurance Need* where such expenditure existed.

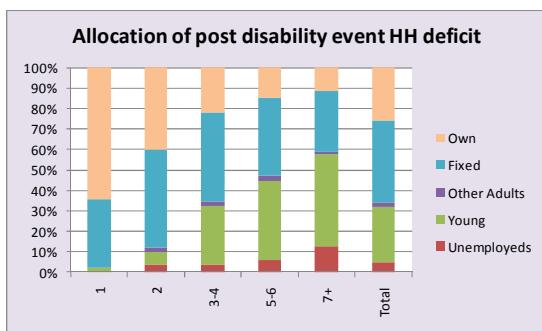


7.4.3 COMPONENTS OF HOUSEHOLD BUDGET DEFICIT (POST EVENT)



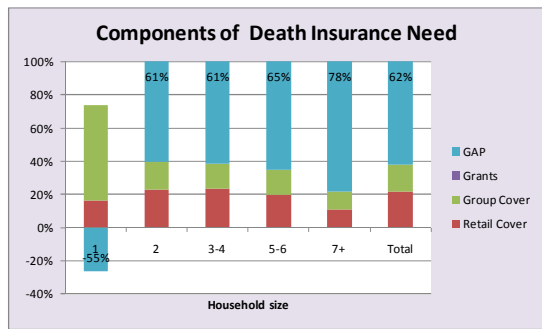
The proportion of the *Household Budget Deficit (post event)* that is related to children increases as the family size increases. This makes intuitive sense.

Conversely (and for the same reason), the proportion of the *Household Budget Deficit (post event)* that is related to own expenditure (*Disability* definition) reduces as the family size increases.

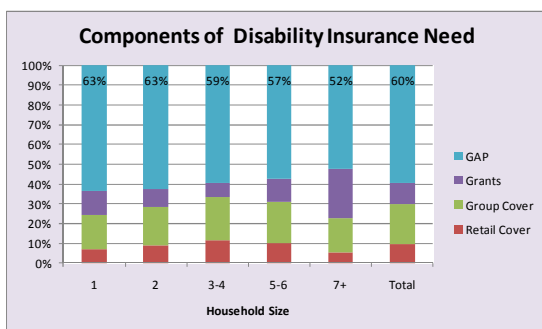


The proportion of household members that are unemployed seems to increase as the household size increases.

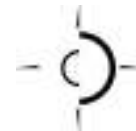
7.4.4 THE COMPONENTS OF INSURANCE NEED



Single member households often do not have a need for death insurance. (It is only where a portion of the income generated by these households is directed towards the support of other households that a need for death insurance exists). As total *Actual Cover* for this group exceeds the *Insurance Need* (where such a need exists), this group is over-insured as far as death cover is concerned.



Disability grant cover is quite a high percentage of the *Disability* cover need for larger (7+) households. This suggests that larger households are typically poorer (allowing more frequent qualification for government *Disability* grants).



APPENDIX A: DEFINITIONS AND PRINCIPLES

Where assumptions were required, we generally aimed to set these at objective “best estimate” levels. However, where this proved difficult, our approach was to rather err in the direction that would provide a lower *Insurance Gap*.

ACTIVE EARNER (OR “EARNER” FOR SHORT)

These are the individuals for which an *Insurance Gap* was calculated and aggregated to arrive at the total gap for purposes of this study.

To be included, an individual had to be:

- South African
- Earning a regular income
- Between the ages of 16 and 65

A person would not be included if they considered themselves to be:

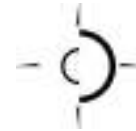
- Unemployed
- Retired
- A housewife / house husband
- A student

ACTUAL COVER

The *Actual Cover* is the total amount of existing cover of various kinds.

Cover types designed to provide for shorter term expenses are excluded (consistent with the definition for *Insurance Need*). We therefore exclude funeral insurance cover, cover from the Road Accident Fund, Workman’s Compensation cover and short-term insurance cover:

- The **Road Accident Fund** provides a level of cover for expenses incurred (medical and legal) as well as loss of earnings that are the result of certain types of road accidents. This source of cover has been excluded primarily since it is unlikely that an individual will take this source into consideration when doing a financial needs analysis. In addition it is noted that the potential overlap between this study and the RAF’s cover is relatively small, insofar as the biggest proportion of RAF payouts relate to settlements other than loss of earnings.



- **Workman's compensation** cover is of a short-term, immediate nature. Since the definition of *Insurance Need* excludes such short-term costs, this source of cover was excluded from the study.
- **Short-term insurers** also provide a degree of death and *Disability* cover. The extent thereof is limited however. Given [a] the fairly small magnitude and [b] the complexities involved in obtaining detailed data from providers this source was pragmatically excluded.

DISABILITY

For purposes of this report, "*Disability*" is defined as "total and permanent" disability, i.e. where it is unlikely for the disabled person ever to be able to work again.

HOUSEHOLD BUDGET DEFICIT (POST-EVENT)

This represents a figure calculated as an intermediate step in the derivation of the *Insurance Need*. It is calculated as the difference between:

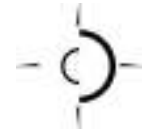
- Household expenses post event (an annual figure): This takes into account the fact that, in a death event, expenses directly related to the earner considered will disappear from the household expense budget.
- Household income post-event (an annual figure): This takes into account income that will continue after the death / disability event:
 - Most notably from other *Earners* and retired household members ...
 - ... but also (small) contributions from the unemployed, students and housewives ...
 - ... and the portion (if any) of income earned by the *Earners* himself / herself which is not dependant on him / her being alive / well.

INSURANCE GAP

The *Insurance Gap* is defined as the difference between the *Insurance Need* and *Actual Cover*.

The *Insurance Gap* represents the total net additional cover that will be purchased by South African *Active Earners* in the following situation:

- Those that are under-insured **purchase additional** cover, so that their *Actual Cover* equals their *Insurance Need*



- Those that are over-insured **reduce their current *Actual Cover*** to reflect their respective *Insurance Need*.
- Those that do not have an *Insurance Need*, but do have *Actual Cover*, **terminate their policies**.

Examples of *Earners* that do not have an *Insurance Need* are:

- *Earners* who are net consumers of household resources (no *Insurance Need* for death cover).
- *Earners* that receive a large proportion of their income from sources independent of their being alive or healthy (for example alimony, contributions from other families, dividends, royalties, rental income etc.).
- *Earners* of single member households, where the full household expenditure is directed to the *Earner* itself (i.e. household expenditure does not include a contribution towards "Support for relatives").

For these *Earners* we zero-ise the *Insurance Need*, but include full *Actual Cover*.

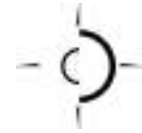
INSURANCE NEED

The *Insurance Need* is the amount of cover required to meet the need that is created by the death and *Disability* events.

It excludes any short-term expenses related to the risk event. E.g. for death event funeral costs were not taken into account. Neither was additional medical or equipment expenditure that may be required as a result of the *Disability*.

It was assumed that the household maintains its current living standards after the death/*Disability* of the *Earner*. Expenditure post death or *Disability* changes only insofar as this event would lead to a reduction or elimination of certain household expenses from that point forward.

In the 2007 study, a second scenario was also used – The "belt-tightening" scenario. It was assumed that the household drops its standard of living after the death/*Disability* of the *Earner*. For this study, as we are also calculating (as a possible response to the *Insurance Gap*) the degree to which households would have to cut expenditure, this definition did not add value anymore.



APPENDIX B: DATA SOURCES AND HIGH-LEVEL APPROACH

INSURANCE GAP

The BMR's "personal information" dataset was used. This dataset represents the full South African population. We extracted only the 12.4 million *Active Earners* – in total 25,491 sample points. Each sample point represents a number of South African *Active Earners*. This number is referred to as the "weight" of the specific sample point. Calculations were therefore all about determining the *Insurance Need* and *Actual Cover* for each of these 25,491 sample points.

INSURANCE NEED

The primary source of information for determining the *Insurance Need* was household income, household expenditure and personal income data as provided by the BMR.

The 2007 study used summarised BMR-information, which required a large number of assumptions to be made. Many of these assumptions became redundant during this study, since the BMR made the full dataset available.

ACTUAL COVER

All information needed to calculate the *Insurance Need* is available on the BMR-dataset, allowing accurate calculation for each of these sample points. This, however, is not the case for *Actual Cover*. The BMR-dataset does not contain any information on product ownership or insurance cover.

Therefore, additional resources had to be used to [1] determine the total level of *Actual Cover* and [2] assign this cover to each of the sample points in the dataset. For this we used two True South developed models (see Appendix D2).

Information used to calibrate these models came from a number of sources:

- AMPS: The parameters for the True South models were derived mostly from AMPS data.
- Life insurers: The long-term insurance industry is the primary source of death and *Disability* cover. A questionnaire was sent to all relevant insurers (ASISA and non-ASISA members alike). Insurers were requested to provide information on the total payments (per cover type, gender, age etc.) that



would be made in the hypothetical scenario where all their policyholders were subject to (separate and independent) death and *Disability* events. Most information was of exceptionally high quality. Where material inconsistencies were identified these were discussed with the insurers. This often led to adjustments being made / new information being supplied.

- Financial Services Board data: To calculate the adjustment required for non-respondents to our questionnaires, we used information supplied by the Financial Services Board.
- Self-insured pension schemes: Self-insured schemes provide a material section of the population with risk benefits. Allowance was made for such cover based on discussions with advisors to these schemes as well as publicly available information.
- *Disability* income grants: Government is a major source of *Disability* cover through its *Disability* income grant and the study paid due consideration to the conditions for payment of these grants.



APPENDIX C: INSURANCE NEED

APPENDIX C1: PERSONAL INCOME AT RISK

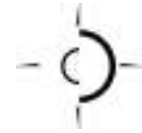
The following table and notes show and explain how the income at risk considered by this study was derived:

Amounts in R'billion	Death	Disability
Total personal income expected for 2010 (<i>Active Earners</i> only)	1 431	1 431
Portion of personal income that is at risk	78%	84%
2010 personal income at risk (<i>Active Earners</i>)	1 119	1 204

Personal income represents income from all sources, including cash salary, employer contributions and deductions, goods and services such as fringe benefits and lump sum payments provided by employers, government and other grants, income from lotteries, income from the sale of fixed assets, inheritances, income from lobola, stokvel and home production as well as income from dividends, shares and director emoluments.

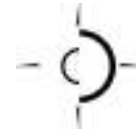
Total personal income earned by South African *Active Earners* during 2010, is estimated at R1,431m. In line with the definition of *Active Earners* this figure excludes personal income from those unemployed, retired, students and housewives. The following table shows how we arrived at the 12.4m identified South African *Active Earners* using as departure point the 48.1m total number of South Africans:

South African Population	Number of people (in million)
Total South African population	48.1
Less children (<16)	-16.9
Less unemployed individuals	-8.8
Less retired individuals	-3.2
Less housewives / house husbands	-2.4
Less adult students	-4.4
South African <i>Active Earners</i>	12.4



Not all personal income is “at risk”: Some of the personal income earned by *Active Earners* would continue even after death or disablement. Examples of such income sources include dividends, royalties, alimony, interest received, rental income received, allowances from other family members and profits from businesses that could be sold in the event of death or *Disability*.

Also, some *Earners* have no need for insurance due to the fact that they are either net consumers of household resources or living in single member households with no financial obligation outside that household. For the death scenarios, personal income earned by such *Earners* are not considered being at risk.



APPENDIX C2: REPLACEMENT RATIO

REPLACEMENT RATIO

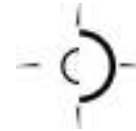
The replacement ratio represents the proportion of the household member's personal income that "will be missed" after the death or *Disability* event. It is calculated as the *Household Budget Deficit (post-event)* divided by personal income at risk (Appendix C1 above).

The replacement ratio can also be presented as the sum of a number of reductions applied to personal income at risk:

	Death	<i>Disability</i>
Personal income at risk	100%	100%
Tax adjustment	-12%	0%
Other adjustments	-2%	-2%
Living standards adjustment	0%	0%
Family size adjustment	-18%	0%
Final Replacement Ratio	68%	97%

Tax adjustment: Some insurance proceeds will not be taxed. Even where proceeds are taxed, income tax will still reduce due to the interaction between lower post-event income and the aggressive nature of tax brackets. Where proceeds are not taxed (mostly life insurance), the portion of personal income that was directed towards income tax was removed. Where proceeds are taxed (mostly *Disability*) we allowed for reduced tax due to lower required post-event income (see below). Actual tax brackets were used to calculate this adjustment.

Other adjustments were made for imputed rent; savings with wealth-creation motive was also removed. To the extent that savings represent provision for retirement, it needs to remain in the expense base. (We are relying on these contributions to provide the household with an income from the intended retirement age). To the extent that it represents wealth creation, it should be excluded from the expense base in line with definitions of Insurance Need (maintenance of current standard of living).



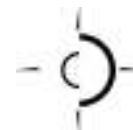
Living standards adjustments: Expense types were allocated to three broad categories:

- Little/no impact (e.g. Food, Furniture, education, insurance)
- Moderate impact (e.g. housing, medical and dental)
- Most impact (e.g. Reading matter, Holidays and Domestic Workers)

The degree to which expenses can sensibly be scaled down depends on the affluence of the specific household. Per capita household income was determined as total household income divided by the number of people in the household, but where children below 16 count for 50% only. Households were then sorted from poorest to richest and assigned a percentile category. For each of the percentile categories and for each of the broad expense types, a percentage reduction in expenses was assumed.

Family size adjustment: For a death event some expenditure will disappear from the household budget. For single-member families it was assumed that only support payments to other households would need to be provided for. For other families, we allocated expenses to different categories:

- “Fixed expenses”: These expenses cannot sensibly be assigned /allocated to any specific member in the household and would also not change much should the family become smaller. Examples include expenditure on housing, washing and cleaning expenditure and domestic worker wages.
- “Adult expenses”: Post-event expenditure is adjusted by taking into account the number of adults in the household before and after the event. Examples include alcoholic beverages.
- “People expenses”: Post-event expenditure is adjusted by taking into account the number of people in the household before and after the event. Examples include food, clothing, reading matter and stationary.



APPENDIX C3: CAPITALISATION MULTIPLE

The capitalisation multiple is calculated as the *Insurance Need* divided by the *Household Budget Deficit (post-event)*, where the *Insurance Need* is calculated as follows:

Step 1: The *Household Budget Deficit (post-event)* is allocated to each of the members of the household. ("Fixed expenses" and education expenses remain in their own categories).

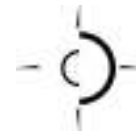
Step 2: An annuity factor is derived for each of these components. The two assumptions required for each of the annuity factor are term and interest:

Term: Generally speaking, the term is the period that household members would have remained dependent on income at risk. As current retirement provision expenditure was retained in the expense base, it is appropriate to allow the dependency duration to cease at what would have been the retirement date. For children dependency is assumed to cease on them leaving the household.

Member of the household	Term used in the annuity calculation
<i>Earner</i> for which the calculation is done	Until retirement age.
Other adults apart from student adults	Minimum of the term and the life expectancy of the considered <i>Earner</i> .
Adult (>=16) students	The assumption here is that a student should be in a position to shortly start earning at least enough to cover own expenses. So term used was until attaining 21 or 2 years if this is more. (E.g. 5 years for a 16-year old and 2 years for a 40 year-old) But no longer than the term used for the considered <i>Earner</i> .
Children	Until age 21. But no longer than the term used for the considered <i>Earner</i> .
Fixed expenses	Term used for the <i>Earner</i> considered in the calc
Education expenses	If there are children in the household, the same term as for Children. Else, if adult students in the house, the same term as for Adult students. Else: 2 years

Interest: An interest rate that exceeds living expense inflation by 1% was assumed. The implicit assumption is that for investments in higher yielding assets (higher end of the socio-economic spectrum), costs, tax and risks will to a large extent negate the potential additional returns.

Step 3: The *Insurance Need* is then determined as the sum of the products of the amounts determined in step 1 (one year amounts) and step 2 (annuity factors) above.



APPENDIX D: ACTUAL COVER

APPENDIX D1: ADJUSTMENTS TO THE ACTUAL COVER DATA

CAPITALISING *DISABILITY* INCOME COVER

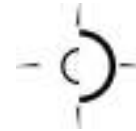
Income *Disability* cover was capitalised by discounting future payments. Payments were multiplied by annuity factors which took account the term to retirement (dependant on current age) as well as whether payments would escalate or not.

ALLOWING FOR NON-RESPONDENTS

Publicly available insurer-specific information was obtained from the Financial Services Board to derive a response factor. The response factor was between 92.5% and 95% depending on the type of cover considered (materially higher, i.e. better, than during the previous study). This factor was used to ratio-up the information received in order to adjust for non-respondents.

EXCLUDING OUT-OF-SCOPE COVER

As the study is concerned with the *Actual Cover of Active Earners* only, we had to (approximately) exclude such (retail) cover held by retired individuals, unemployed individuals, housewives and adult students.



APPENDIX D2: TRUE SOUTH OWNERSHIP- AND COVER MODELS

The *Actual Cover* had to be allocated to each of the 25,491 sample points on the BMR-dataset. This was done separately for individual death cover, individual *Disability* cover, group death cover and group *Disability* cover using two True South-developed models:

- **TSPO-model**: The True South Product Ownership model returns the probability of a South African *Earner* having death or *Disability* cover based on supplied information such as education, age, income, marital status and family composition.
- **TSCL-model**: The True South Cover Level models return the level of cover given that cover does exist based on similar information required by the TSPO-model.

Genetic algorithm technology³ was used to solve the optimization problem of fitting the model parameters. As mentioned elsewhere, input for deriving the parameters were obtained from a wide variety of sources such as AMPS, Financial Services Board information and the Insurer questionnaires.

The total *Actual Cover* for each of the sample points was derived by multiplication of the probability of being insured (from the TSPO-model) with the average level of cover (from the TSCL-model) for each of the four cover types (death vs. *Disability* and retail vs. group).

³ A genetic algorithm is an experience-based technique for problem solving that mimics the process of natural evolution (i.e. using concepts inspired by natural evolution, such as inheritance, mutation, selection, and crossover). This approach is routinely used to generate useful solutions to optimization and search problems, including previously unsolvable, complex non-linear problems.